THE GLASS INDUSTRY
THE JOURNAL OF GLASS MANUFACTURING

The Glass Industry-1959

by H. E. Simpson

STATE UNIVERSITY OF NEW YORK COLLEGE OF CERAMICS
ALFRED UNIVERSITY, ALFRED, N. Y.

● In 1959 the glass industry experienced a very successful year in spite of the fact that most areas were affected in some way by the longest steel strike in the country's history. The production of steel was resumed on Nov. 7 for an 80-day "cooling off" period, and the strike was finally settled in January with a 30-month contract.

Flat glass production, comprising window and plate glass, was most encouraging owing to an early introduction of the 1960 automobile models, together with a high level of activity in building and construction. This combination resulted in the highest production of flat glass since 1957.

Imports of window and plate glass still plague the industry, and will no doubt continue to affect the flat glass field in the future. Successful competition apparently can be met only by increased mechanization and constant lowering of production costs.

Shipment of glass containers has also continued at a high level, and 1959 will likely equal and possibly exceed any former peak production for these products. This branch of the industry has attained over $1 billion annual figures with production in excess of 21 billion units.

Similar impressive growth records are being made in the field of glass fibers and electronics, the sales volume of the former being estimated in excess of $250 million.

CORPORATE EXPANSION IN 1959

American-Saint Gobain Corporation

● Begins financing program to raise funds for new $50-million plate glass manufacturing plant in Greenland, Hawkins County, near Kingsport, Tenn. scheduled for completion during 1962.

● Will become third producer of plate, sheet and rolled glass in U.S.; annual capacity, about 40 million square feet of ¼" plate glass.

Anchor Hocking Glass Corporation

● New glass container manufacturing plant begins production at San Leandro, Calif. This is one of three Anchor Hocking plants on West Coast operated by subsidiary firm, Maywood Glass Co.

Ball Brothers Company, Inc.

● Begins construction of multi-million dollar glass container manufacturing plant at Asheville, N.C., 120,000 sq. ft. warehouse built first, office building and manufacturing building to follow.

Brockway Glass Company

● Central laboratory and research center completed at main plant in Brockway, Penna.

• Will break ground for multi-million-dollar glass container manufacturing plant in the Minneapolis-St. Paul area in early Spring, 1960; on stream by Fall, 1960, manufacturing flint and amber glass containers for the company's food, beverage, Rx, beer, liquor, pharmaceutical and proprietary divisions.

Brockway Glass and Tygart Valley

• Merger completed, making Tygart a wholly owned subsidiary of Brockway which now becomes fourth largest glass container manufacturer in U.S.

Chrysler Corporation

• Installing glass-fabrication machinery in reconverted stamping plant, Detroit, in preparation for manufacturing its own glass. Company expects eventually to produce about half of the windshields, windows, and head and tail light lenses for its cars and trucks.

Corning Glass Works

• Leasing kiln facilities at Paden City, West Virginia, in expansion move for finishing Corning Ware.

E. I. du Pont de Nemours & Company

• Ceramics division of electrochemical department organized.

Foote Mineral Company

• Constructing $2.2 million research and engineering building on 53-acre research and engineering center near Exton, Pa.

A. P. Green Fire Brick Company

• New $2-million refractory plant at Tarentum, Pa., will produce magnesite, magnesite-chrome, chrome, magnesite, chrome and allied products.

Harbison-Carborundum

• Jointly owned subsidiary established by Harbison-Walker Refractories Company and Carborundum Company for the engineering, manufacture and sale of fused refractories.

Harbison-Walker Refractories Company

• New Garber Research Center formally dedicated in June. Emphasis will be on fundamental and applied research.

International Minerals & Chemical Corp.

• Now operating new feldspar mill near Custer, South Dakota, which replaces former mill destroyed by fire in July, 1958.

Iroquois Glass Limited

• New Candiac plant near Montreal, Canada, in production: 300,000 units of flint, green and amber containers per day.

Knox Glass, Inc.

• Purchases Buck Glass Co.

Laurens Glass Works

• Construction begun on glass container manufacturing plant at Henderson, N.C. Will produce containers for soft drinks, processed foods and household chemicals. Will also operate applied color decorating department.

Libbey-Owens-Ford Glass Co.

• Technical Center expanded at Toledo, O., by more than 38,000 square feet.

Metro Glass Co.

• Constructing a glass container manufacturing plant in Carteret, N.J.

Owens-Illinois Glass Co.

• Having exercised option to buy physical assets of Vidrio, S.A., in Bogota, Colombia, Company will start operating third Latin American glass container plant.

Constructing multi-furnace glass container plant on 24-acre site, Inner Harbor Industrial Canal, New Orleans, La. This will be the 17th O-I plant for manufacture of bottles and jars.

Pittsburgh Plate Glass Co.

• Establishing central offices of International division in Cuba.

• Completes Pennvernon window glass plant at Decatur, Illinois.

Permaglass, Inc.

• Begins work on 50,000-square-foot plant seven miles south of Toledo, O.; will be completed by Spring, 1960, at cost of $250,000 plus.

H. K. Porter Company, Inc.

• Refractories Division opens $12-million plant, Pascagoula, Miss.

Republic Glass Corp.

• Completes the first window, sheet and plate glass plant in Philippines, at Manila: 16,000 metric tons a year, expected to reach 21,000 tons by 1960.

Thatcher Glass Manufacturing Co.

• Begins construction of $3.5-million glass container plant in Tampa Industrial Park, Tampa, Fla., for Florida market, which will be completed by Spring, 1960, with annual capacity of 100 million glass bottles. Thatcher's eighth plant in U.S.

Walsh Refractories Corp.

• Completes new factory for manufacture of FC-101 premium fusion cast refractory in St. Louis.

FLAT GLASS AND STRUCTURAL GLASS

The production and shipments of both window glass and plate glass for the first three quarters of 1959 are given in Table I, and estimates of total production for 1959 are made from these data. The remarkable increase in production in this section of the industry has been due largely to the fact that in 1958 a prolonged strike

markedly reduced the total production for that year. In 1959 5,588,733 automobiles were manufactured. This production, coupled with an early introduction of the 1960 models, provided a heavy demand for flat glass, which was further enhanced by continued brisk activity in the construction field. There has also been a marked increase in the demand for glass building facing materials, such as the clad-wall construction, and double-glazing has also been on the upswing.

TABLE I

PRODUCTION AND SHIPMENTS OF FLAT GLASS*

	Production[1]	Shipments	
Sheet (window) glass (not rolled) including colored:	1,000 boxes of 50 sq. ft. each single strength and equivalent		
	(Quantity)	(Quantity)	(Value $1,000)
First Quarter	5,658	5,514	28,438
Second Quarter	7,045	6,781	35,186
Third Quarter	7,098	6,725	34,635
Total	19,801	19,020	98,259
Estimated by author 12 months 1959	26,401	25,360	131,045
Plate and other flat glass[2]		1,000 square feet	
First Quarter	186,680	65,150	28,831
Second Quarter	223,003	87,288	42,916
Third Quarter	174,951	70,932	32,506
Total	584,634	223,370	104,253
Estimated by author 12 months 1959	779,512	297,827	139,004

* Source: "Facts for Industry"—U. S. Department of Commerce
[1] Production figures include the quantities shipped as well as the quantities incorporated into other products manufactured by establishments producing glass.
[2] Includes data for wire and rolled glass, translucent, opaqued, roughed, or otherwise impressed. Excludes information for block and tile.

Corning Glass Works Building

The versatility of glass as a building material is strikingly demonstrated in the new Corning Glass Works Building at 715-717 Fifth Avenue, New York City which is clad in 4½ acres of green Solex heat-absorbing glass held in slim anodized aluminum frames.

White non-solarizing Carrara glass, was chosen in two finishes: one ground and polished, and the other a soft suede for contrast. A prism design snowflake pattern, 48 inches in diameter, was laminated to the center expanse of white Carrara. Two 16-foot high panels on either side are the largest lights of the opaque structural glass used to date in an exterior application.

Improved Glass Seal

Libbey-Owens-Ford introduced a new "Glas Seal" thermopane unit of very light weight, using single strength A-quality window glass. It is suitable for installation in double-hung and other conventional window sash. This development is believed to be an important step in all-around-insulation glazing in modern homes, including those of moderate cost.

Increase in Automobile Glazing

In the automotive line, the forward step into new, larger areas of glass is being continued. A rear window of heat-treated glass, shaded with a new mineral coating has been made to go along with the shaded windshield announced some years ago. This new back window shading uses the principle of reflection of heat waves in addition to the heat-absorbing functions built into the glass itself.

Wall Panel: Lights, Heats, Cools Room

A full-scale wall panel of glass that promises to light, heat, and cool the home has been revealed by the Westinghouse Electric Corporation. The glass panel responds to a set of dials which can change its temperature from a low of 55° to a high of 120°F and vary the intensity and color range of the light source. The versatility of the "hot-cold-light" panel, which combines the latest advancements in electroluminescent lighting and thermoelectric cooling and heating has been demonstrated. The panels are 6 feet long, 4 feet high, and glow with a diffused light.

Flat, Square Fluorescent Light

The General Electric Company has developed a flat, square, glass fluorescent lamp which requires less installation space than present types of lighting equipment. The light measures about 1 foot square by 1 inch thick and is made of 2 plates of glass containing a series of channels. These channels guide an electron stream across a coating on the glass, causing it to glow. The thin light would require less ceiling and wall space for mounting, compared with conventional fluorescent tubes or incandescent bulbs. Said to give more light than a conventional 100-watt incandescent bulb, the new lamp uses about half the electricity. It is now in the experimental stage, and present development is being carried out at the Nela Park Laboratories.

New Curtain Wall Controls Sunlight

A new curtain wall consisting primarily of glass and containing built-in daylight control is being produced by Owens-Illinois. Basic elements of the system are vertical aluminum struts, erected on 4- or 5-foot centers, to which are fastened standard, interlocking prefabricated panels, 2 inches thick. The panels are available with solar-selecting glass units in white, yellow and green, transparent glass, ceramic-faced glass units, windows and porcelain enamel.

The glass units incorporate a prismatic system which allows selective light transmission. The prisms act like a mirror, reflecting most intense sunlight back into the sky. The curtain wall is double gasketed, horizontally and vertically; all panels, as well as the vertical struts to which they are bolted, and the finish batton strips, have weatherproof gaskets. No field caulking is required, and the wall may be installed by any competent erector with a little preliminary instruction.

Glass Blocks

Pittsburgh Corning Corporation has introduced a slim, rectangular block, 4 inches wide and 12 inches long which has an acid-etched appearance on its inner faces, the outer faces being smooth. In addition to the standard block, it is available with a white fibrous glass screen in the center, which acts as an additional light diffuser and enhances the good insulating value of the

block. The 4″ x 12″ block is also available with the blue-green "Suntrol" fibrous glass diffusing screen which cuts down glare and instantaneous heat gain still further.

The new shape, based on the 4-inch module, may be used in combination with the company's standard 12-inch, 8-inch, and 6-inch square blocks. It was developed after surveys of leading architects showing the need for a rectangular shape to allow greater freedom of design and may be used either vertically or horizontally, alone, or in combination with other glass blocks or materials.

This 4″ glass block has an insulating value equal to that of an 8-inch concrete block wall; it will also be produced with all the translucent ceramic colors used on PC glass blocks which are currently available on architects' specifications.

Cellular Pipe Covering

Pittsburgh Corning has also developed a new line of low-cost rigid cellular glass insulation for hot and cold commercial piping applications—a special Foamglas insulation, called "Stay-Dry," for commercial piping in a temperature range of 35° to 350°F.

Because the insulation is made up of many tiny glass cells—each an insulating air space—it acts as its own vapor barrier and is said to be completely impervious to water, and to protect pipe against rust and corrosion. Being inorganic, it cannot burn, eliminating the necessity for installing fire-proofing materials, a feature described as especially significant for commercial and institutional structures such as hotels, hospitals, schools, and office buildings.

CONTAINER GLASS

In 1959, for the fifth successive year, U. S. shipments of new glass containers reached a very high level, estimated at 161 million gross or 23 billion units. It has been conservatively estimated that by 1975 the industry will produce approximately 47 billion containers.

Trends and New Developments

Styling of containers for a less commercial appearance. Excellent examples are found in the apothecary container for vitamin pills. The sales impact for containers of this type is derived from their attractiveness, appropriateness, and the fact that they can be used for table service. Recent examples are the "hour-glass" and trylon designs created for Abbott Laboratories.

Lightweighting. One of the most interesting developments has been the acceptance of new style and lighter-weight, one-way beer bottles. A number of glass manufacturers have been producing trial quantities of a new container weighing only 6 ounces—14 per cent lighter than standard beer bottles. This new bottle is not only a space-saver, but also permits faster line speeds and more efficient automatic case loading. Packagers of products other than beer are vitally interested in the experiences of brewers with this departure from tradition.

Lightweighting, of course, has been in progress for a number of years and has involved many types of glass containers, particularly food packages. In general, glass containers have shed one-third of their weight during the past 25 years. Because glass is presently exploiting only about 1 per cent of its measurable laboratory strength, there is good reason to hope that further, perhaps sensational, gains can be made in regard to improved strength.

King size. One of the most strategic concepts for packagers involves the king-size container. This large-sized container has found new favor by producers of beverages, milk, pickles, detergents, and the like. The packager obtains greater shelf display and better market penetration; and the customer, because of once-a-week shopping, increased entertaining, and larger families, is better served by the larger quantities. However, there is another equally important consideration: the fact that king-size packaging—unlike multi-unit packaging—represents a basic saving in container cost. Although the package is larger and requires more material, only one container and one closure, and no additional carrier, are involved. It would appear that additional opportunities exist for king-size packaging, especially in areas where extra cost for carriers might be the factor in making multi-units impractical.

An example of king-size packaging that merits careful study because of the merchandising implications it contains is found in the trend to half-gallon and gallon containers for milk. According to the United States Department of Agriculture, the consumption of whole milk in gallons increased from 5 per cent (1955) to 7 per cent (1956) to 8 per cent in 1957. In half gallons, the increase was from 22 per cent to 35 per cent to 40 per cent for the same years. The economy of these containers has enabled returnable glass bottles to regain ground in supermarkets, where paper containers had virtually eliminated milk in glass. From 40 to 50 trips for jumbo bottles are reported by dairies, resulting in extremely low container costs. Savings to the customer are estimated to be from 1 to 3 cents for half gallons and from 7 to 12 cents for gallons.

Coatings. Because preservation of the container surface protects glass, coatings that prevent the damage of bumps and scratches and provide lubricity to prevent seizing, galling, and jamming are of considerable importance for certain types of containers, particularly on high-speed lines.

There are two principal differences in coating methods. Some coatings are applied in the lehr during the annealing process when the glass is being cooled from forming to room temperature. Coatings of this type are polyoxyethylene stearate and polyethylene glycol; both give lubricity and gloss.

Application is made at about 250°F to avoid thermal shock; however, the coating comes off in a water rinse and protection exists only from the lehr until the container is delivered to the filling line. Another lehr coating employs sulfur dioxide, which is introduced in the lehr when container temperature is about 700°F. The sulfur treatment tends to leach sodium from the glass and toughen the outer "skin." Practically all returnable bottles that must encouter internal or external pressure are given a lehr coating of some type. The second process applies the coating, usually by means of a spray, after the container has left the lehr. One type of coating used in this process is a silicone solution. It is easy to apply

and has many desirable properties, but it has some disadvantages including the fact that special types of label adhesives are required because of silicone's anti-adherent properties. Recently, a new and improved, semi-permanent, wax-type coating has been developed, and, reportedly, it does not interfere with label adhesion.

Table II lists six major types of coatings developed and perfected in recent years and rates their performance against the several necessary and desirable coating characteristics.

Glass for beverages. In 1959 virtually all wines and liquors, approximately 99 per cent of all soft drinks, and 65 per cent of packaged beer were merchandised in glass. Liquor bottles have tended toward slender, round shapes with tall labels to make the package look large and to make it easy to handle. The new beer container, on the other hand, is streamlined in the interests of lighter weight, easier handling, and lower costs. These factors are of special merit for beer because of its competitive struggle with cans for the beer market. Bottlers of soft drinks are taking advantage of the fact that a variety of sizes is available, thus enabling them to serve and reach their total markets more efficiently. Ceramic color labeling is also being viewed with new interest.

A major factor in this field is the economy of the returnable bottle. Although, this requires extra effort for the consumer and for the retailer, there are definite advantages for both the consumer (taste and economy) and the retailer (bringing customers back to the store).

Glass for drugs. Glass containers are a necessity for meeting the complex packaging requirements of the drug industry. Containers used for drugs are generally available in clear flint or amber color. Blue, emerald green, and opal glass colors may be obtained from a limited number of sources. However, blue, green, and flint glasses transmit ultra-violet and violet light on wave lengths of about 3,200 to 4,000 angstrom units and do not meet the U.S.P. specifications for light-resistant containers having complete protection against ultra-violet, violet, and violet-blue (2,900-4,500 angstrom). Amber is usually used for drugs that have extreme sensitivity in this range. Most glass, including flint, gives some protection in the far ultra-violet units (2,900-3,200 angstrom units), and emerald-green gives some protection in the visible violet-blue range (4,000-4,500 angstrom spectrum).

Glass for cosmetics. Since the products of the cosmetic industry are concerned chiefly with the ingredients of "beauty" and of catering to the dictates of good grooming, the versatility of design and decoration provided by glass becomes highly important. Glass containers may be manufactured in a multiplicity of shapes, designs, and contours. These design characteristics may be utilized to enhance the display of the product and offer consumer convenience.

Glass for household and chemical products. Packaging progress in this field has been exceptionally marked in recent years. The increase in the number of homes, the move to suburbia, and the trend to do-it-yourself have stimulated a vast increase in products for the home, lawn, garden, hobbies, and recreation. Moreover, there is a premium placed on worksaver products and packages because the modern home is run without benefit of servants, and everyone has progressively heavy demands made on his leisure time.

The effect of all this increase is to create opportunities for the packager. Naturally, glass containers are important in this field because so many of these convenience, work-saver products—cleansers, liquid starch, bleaches, deodorants, insect sprays, and the like—require the protective properties of glass. Also, glass offers the convenience of easy closure and reclosure and functional dispensing.

Better marking and labeling on glass. Applied-color labeling, or ACL, is used by the glass industry to denote the fired-on, vitreous-color decoration on glass bottles, jars, and ceramic containers.

When labeling is properly designed to take advantage of the qualities inherent in this method, the bottle and its contents are immediately upgraded because of its attractiveness, appearance, and permanence of the label. Consequently, its cost against paper labels, even on one-trip containers, is competitive for many uses. The cosmetics industry has been taking more frequent advantage of these qualities.

The designs for milk and beverage bottles have been somewhat bolder and coarser. The re-usable multi-trip feature of ACL containers is the important economic factor in these uses. Refinements in techniques and materials have provided a decorative medium which is

TABLE II

COATINGS FOR GLASS-COMPARISON OF PROPERTIES*

	Sulfur	Metallic Oxides	Non-permanent wax type	Semi-permanent wax type	Resins	Silicone oils
Invisible film	No	Iridescent sheen	Yes	Yes	Varies[1]	Yes
Easily applied-as by spray from water solution, or as a gas	Yes	No	Yes	Yes	Yes	Yes
Water insoluble after application (hot and cold water)	No	Yes	No	Yes	Varies[1]	Yes
Water wettable after application	Yes	Yes	Yes	Yes	Yes	Yes
Good lubricity—wet and dry	No	Yes (dry)	No	Yes	Varies[1]	Yes—dry wet[1]
High puncture strength of film	No	Yes	Yes	Yes	Yes	No
Non-toxic	Yes	Yes	Yes	Yes	Yes	Yes
Permits easy labeling (hold labels)	Yes	Yes	Yes	Yes	Yes	No

* Basic form and information for this table developed by Anchor Hocking Glass Corporation.
[1] Possible weakness in material for property so marked. Further development seems to be needed.

difficult to duplicate in permanence, color, and effect. A good range of colors has been available for a number of years. Recently additional refinements in color effect have been achieved. A transparent flux or crystal frit is used with certain clear colors to achieve remarkable glass-staining effects.

Designers still have not taken full advantage of these technical offerings. A logical extension of this achievement has been to apply the crystal frit in considerable thickness to give the illusion of embossed glass. A manufacturer can now use stock bottles for limited runs and imprint his trademark, logo, and the like in the glass and still save special mold costs. There are other methods—like spray and veiling—which may be used to apply fired-on color, but they are generally employed to supplement the decorative effect of ACL.

Briefly, the process begins with an open mesh material, which is stretched tightly on a wooden or metal frame. The mesh is impregnated with a photosensitive emulsion, exposed and developed in a manner which parallels photoengraving, except that there is no plate to be etched. Instead, the resistant film becomes a stencil which is firmly impregnated with the mesh material. The stencil screens are clamped to a machine, usually semi-automatic, which moves the screen in a straightline stroke across the container which is being turned and printed. Directly over the axis of the bottle is a wedge-shaped rubber squeegee which forces the glass paint through the open areas.

This glass paint is a vitrifiable pigmented mixture containing oils or waxes which act as temporary vehicles. The organic materials burn off in a lehr at a temperature below 900°F. The temperature rises, and the remaining inorganic powder coalesces at from 1000 to 1,150°F. (depending on the materials) into a glossy, impervious color, permanently fused to the glass. Continuous mesh-belt furnaces average about 100 feet in length. The firing cycle may take from 1½ to 3 hours. The variation depends chiefly on the glass and its wall thickness, because reannealing is necessary to maintain strength.

Improvements in handling and production have kept ACL prices from rising with other costs. Custom printers, who at one time specialized in short runs, find that they can offer greater economies in runs of more than 10,000 pieces. The advances in printing technique have increased legibility and accuracy and have contributed substantially to the general attractiveness of the finished glass container. Refinements in gold printing pastes have led to the mass production of handsomely decorated containers. These gold pastes (or other precious metals such as platinum, palladium, rhodium) are formulated with precisely controlled laboratory techniques.

Unit Melters

There are now 70 of these Unit Melters located throughout the world, and 1 or 2 more will be placed in use soon. The steady year-to-year increase indicates that the Unit Melter continues to compete successfully with older types of regenerative and recuperative furnaces in areas where fuel costs are high and where the daily output required is less than 55 tons.

Up to 1958, the melting capacity of Unit Melters ranged from less than 10 tons to a maximum of 40 tons of glass per day. During 1959 the first 10′ x 40′ Unit Melter was completed. It is capable of a daily output of 55 U.S. tons.

The heat recovery systems (waste heat boilers) used on Unit Melters at H. Heye Glasfabrica in Germany were described in detail in the October, 1959, issue of THE GLASS INDUSTRY. This article described an economical method of producing steam and power from waste heat. Other melters employ metal recuperators to preheat combustion air.

The larger regenerative type furnaces continued to show increased efficiency and longer life during the year as a result of modern design, good selection of refractories, and improved control of operating conditions.

Gallo "Flavor-Guard" Color

During 1959 there were some new compositions developed as a result of the demand for containers that would resist chemical attack. The introduction of the Gallo "Flavor-Guard" color, which has the property of absorbing ultra-violet light, created an interest in the development of emerald green glasses having this same property. Several such glasses were introduced and carry such descriptive trade names as Ultrasorb, Filtre-Ray and Filtrex, among others.

Improved Automation

There have been no major advances in feeding, forming, conveying, or annealing of glass, although there have been the expected refinements of process and of equipment to result in increased efficiency of operation. The demand for increased productivity has also led to improvements in the equipment used in double-gobbing. Equipment is now available for producing a much larger bottle by double-gob process and for forming smaller bottles at increased speeds.

During 1959 the R-7 Glass Forming Machine was introduced to American glass manufacturers. The R-7 machine is a feeder-fed, continuous rotary blow-and-blow machine (final blow by means of vacuum), with 7 mold stations and is used for forming narrow neck ware. Production speeds at the present time range from 20 to 55 containers per minute.

Improvements continue in the field of automatic inspection. A new type of check inspector has been developed to inspect lug and thread finishes. This machine features greatly increased sensitivity and a novel means of locating and adjusting the check detector heads. Another new piece of equipment added to the automatic line is the glass house bottle packer. This device is capable of handling lightweight bottles and jars from a single inspection line to corrugated cartons.

FIBERGLASS

The glass fiber industry has enjoyed a most profitable year; demands for building materials and the continued expansion and development of new glass fiber products have brought activities to a very impressive level. Sales volume for the entire industry is estimated to be in excess of $350 million. Total production is believed to be approximately 250-260 million pounds for the year 1959.

Expansions

Ferro Corporation's Fiber Glass Division, Nashville, Tenn., began a $2,700,000 expansion program designed to alleviate the critical shortage of fiber glass reinforcing materials in the plastics industry. To be finished in late 1960, it will include an additional glass smelting tank, fiber-producing bushings, fabricating machines and warehouse area. Coupled with a previous $700,000 program the new expansion is expected to increase production capacity by 75 per cent.

Fischer & Porter formed the Warminster Fiberglass Company to produce fiberglass-reinforced plastic parts. The firm is independent of the parent organization.

At Johns-Manville Fiber Glass Division expansion plans were made for the company's Waterville, O., and Parkersburg, W. Va., operations, while the Defiance, O., fiberglass blanket insulation materials plant was scheduled to receive two insulation manufacturing machines, to be housed in separate 15,000 sq. ft. wings.

Owens-Corning Fiberglas Corporation moved its basic and applied research and its product testing laboratories from Newark, O., to a 150-acre tract near Granville, O. The new laboratories consist of four buildings with a total floor space of 100,000 sq. ft. The company began construction on a multi-million-dollar Fiberglas textile yarn plant in Aiken, S.C., situated on a 350-acre site three miles east of Aiken. It will be equipped with the most advanced processing facilities for fibrous glass textile materials when it is finished later this year. Yarn production will supply Owens-Corning's three textile plants located in Anderson, S.C., Huntingdon, Pa., and Ashton, R.I.

Pittsburgh Plate Glass Company is also increasing their fiberglass yarn production with an expansion of 24 furnaces at their Shelby, N.C. plant. The additional furnaces will give the plant an annual rated capacity amounting to more than 40,000,000 pounds of textile yarn.

New Developments

Historically, the first major use of fiberglass was in insulation. Other home uses range from roofing to wiring, and from acoustical ceilings to gutters and downspouts.

In this field, Owens-Corning has put into practice a new all-fiber process of making insulation, so that it can be compressed into packages one-third smaller than those previously used.

Johns-Manville Fiber Glass Division is offering a new foil-backed insulation which represents that company's first entry into the residential market. Pittsburgh Plate Glass Company has announced that it, too, will branch out from its insulation to enter this competitive field.

The great strength for the future rests not only in output of products of fiberglass alone, but also in the unlimited opportunities for combination of fiberglass with an ever-growing host of other materials.

Decorative Fabrics

Activity is also apparent in decorative fabrics. Recent technical improvements, both in the basic manufacturing and in finishing, have made it possible to produce finer quality continuous-filament yarns, which have greater bulk and are much easier to dye.

Out of this development has come a broad new line of soft-textured fabrics, woven by J. P. Stevens, Burlington Industries and others. These are then converted to high-style drapery fabrics for the decorating trade and for the home sewing market. In curtains, too, fiberglass is proving increasingly popular. As recently as 1955, only one million pairs were sold in the United States. In 1956 the figure more than doubled, to 2.5 million, and again in 1957 to 5 million.

Reinforced Plastics

Perhaps the most explosive of today's market is the whole field of reinforced plastics. In these strong, rigid lightweight materials, which can be molded into complicated shapes, the plastic or resin is usually polyester. Fiberglass (or sometimes asbestos or nylon) is used to reinforce it, in much the same way steel reinforces concrete. In 1957, production of reinforced plastics ran to some 168 million pounds, of which about 55 million pounds was fiberglass, as compared with 45 million in 1956 and 7.5 million in 1951.

Reinforced plastic for civilian use got its start in corrugated and flat sheets for construction. These translucent panels, now provide the biggest single market, are used widely as patio and breezeway roofing, fencing, and partitioning, to cite a few examples.

Polyester resin reinforced with glass fiber now goes into about 25 per cent of all small outboard motor boat hulls and, according to *Modern Plastics*, "the material is plainly destined to become the basic building stock of all types of boats except large commercial ships."

While these boats were novel only a few years ago, wood boats may be the novelty in the future. Between 1946 and 1953, 4,000 RP boats were built; in 1954 some 16,000; in 1956, 40,000; and in 1958 about 60,000, out of an estimated total of 400,000 small craft. In 1959 it is estimated that as many as 75,000 were built. Industry sources predict that by 1965 perhaps 60 per cent of all small boats will be of fiberglass. That would mean a market for some 43 million pounds of glass.

During 1959 the glass fiber industry has raised its share of the $2-billion pleasure boating market. One good token was the fact that at New York's Motor Boat Show early last year 34 per cent of all boats shown were made of glass fiber. Meanwhile, an increasingly large number of parts for outboard motors are being made of glass fiber.

ELECTRONICS

The long-range estimates in Table III of what the future holds in the electronic field have been taken from *The Home Entertainment Market for Initial Equipment and Electron Tubes 1959-1965* by the Radio Corporation of America.

Television saturation as of January 1, 1959, was estimated at 86 per cent of total households; by 1965, it is expected to reach 93 per cent. Because of the high level of saturation, sales are almost wholly dependent on the percentage of TV households which replace sets each year.

(*Continued on page* 104)

Study of Glass and Mold Temperatures in Commercial Glass Container Forming Operations

by H. H. Holscher, J. C. Coleman and C. C. Cooke

OWENS-ILLINOIS TECHNICAL CENTER, TOLEDO, O.

Methods and procedures have been developed for measuring both glass surface and mold surface temperatures obtaining in the manufacture of glass containers. Data are given for several typical types of glass containers manufactured in two colors of glass on the Owens machine and for flint wide-mouth items made by a press-and-blow process.

The methods of temperature measurement described are unique, and it is believed they will be found applicable for studies of such temperatures obtaining in varied processes of glass fabrication.

1. Introduction

● SOME TWENTY YEARS AGO the authors initiated a study of the temperatures existing in glass and molds during commercial glass container forming operations. This study was one aspect of an over-all analysis of temperature problems from the furnace through the forming range and into the lehr. The primary purpose of the work was to attain an appreciation of the temperature variations which exist over the glass, the blank mold, and the blow mold, with the ultimate aim of analyzing the processes critically for the guidance of future developments.

Many new techniques of measurement were evolved in this work. In the intervening years since this study, there have been two major contributions of similar nature to the literature. In England, Turner and coworkers[2] reported on general glass temperatures in a study of hand and machine processes. Thermocouples, optical pyrometers, and calorimetric methods were used for glass temperature measurements. By this means, a picture of the more or less average temperature situation was evolved and related to glass viscosity. A table summarizing these results was given by the senior author[1]. Turner's mold temperature data are very sketchy. They were measured either by inserting thermocouples within holes in the mold, usually drilled to a slight distance behind the interior mold surface, or by contact pyrometer methods. Only a very general picture of mold conditions was secured. Any surface temperature data reported by Turner, either on glass or mold, must be cautiously evaluated on the basis of the techniques which were used.

The second study of importance was reported by Trier[3] in 1955. For mold temperature, Trier used a thermocouple assembly with a face thickness of 0.016 inch and placed the assembly flush with the interior surface of the mold. This procedure is a great improvement over that of Turner, but the data are still tempered by the effective thickness of the junction of the thermocouple. While Trier compared his assembly with another more complex one, where the junction was much nearer the interior mold surface, and claimed comparable results for the two methods, it is the writers' feeling that in many cases the two methods should not be expected to yield equivalent results. It is believed that the method of thermocouple assembly used by the present writers offers less disturbance to heat flow and greater opportunity for surface measurement. The methods are, however, fundamentally the same as Trier's. While Trier reported on only two or three positions within any one mold, the present authors have measured a great many more locations. In many cases, usage of 15 to 20 thermocouples per mold has been common. Concerning glass temperature measurements, Trier abandoned the idea after preliminary tests.

A completely unique approach to the measurement of glass surface temperature was made. The method approached the demands of proper immersion of the lead wires adjacent to the thermocouple junction so that errors of conduction away from the junction were mini-

Presented before the Fifth International Congress on Glass, Munich, Germany, June 30, 1959.

mized. The method also allowed a complete recording of the temperature.

In this way the results reported on glass surface temperature are felt to be unique, even though the work was done many years ago. Similarly, because of the studies of temperature gradients over the mold surfaces, the present delayed reporting of these early data is felt to be desirable.

Aspects of glass-working range were obviously a part of the over-all studies. Such data are only incidentally discussed in this report, since there is general agreement on this phase of glass technology in the literature. However, certain facets of the working range temperature data are necessary as an introduction to the glass surface temperature measurement problem. Obviously the data on the machine must be consistent with the temperature existing as the glass is fed to the unit. Likewise, the glass temperatures at discharge of the bottle must be consistent with expectations from the viewpoint of deformation of the bottle after it leaves the blow mold. These will be appropriately introduced in Section 3.1.

2. Methods and Procedures

2.1. Thermocouple Immersion Factors

In using thermocouples the wire obviously conducts heat to or away from the junction if the wire is hotter or colder than the junction. The size of the bead junction should normally approximate the diameter of the wire. If this is set, then a thermocouple should be inserted a definite distance into a constant temperature so as to read this temperature accurately—that is, the immersion of the wire adjacent to the junction should also be at the same temperature as the junction. This isothermal situation applies for a plane as well as a volume. If isothermal planes are available, then the lead wire should be placed within the appropriate plane for a definite "immersion" distance. This is the case for a surface temperature. Of course, a thermocouple can never read precisely if there are temperature gradients in all directions. Many such usages are made, but there is always a question of heat conduction from or to the junction along the wire, depending upon the gradients along these wires. While such conditions may usually be comparable from one time to another, and thus be useful for control purposes, they rarely give exact temperature measurement. As Sosman says[7] "The best position for the wires . . . is parallel to the isotherms."

In all the work on glass temperatures, attempts have been made to produce the best condition for proper thermocouple immersion within an isotherm—either a surface or a volume. In most cases with 0.012 inch diameter wire, ¾ inch of such immersion has been attained—certainly enough to minimize conduction away from or to the thermocouple junction[a]. In most cases, no absolute isothermal situation exists, but the best such one available has been selected. Bare thermocouple wires have been used, since obviously the immersion factor increases greatly with diameter—and usually protection elements or insulation increases such errors where any gradient exists[a].

a. The immersion factor is variously recommended as from 10 to 50 diameters of the bare wire, or of the whole element if a protection tube is used.
b. See footnotes (d) and (e), sect. 3.3.

2.2. Glass Temperature Method

A scheme of placing thermocouples in the blow mold cavity so as to record surface glass temperatures was evolved. This was known as the mica setup, which is illustrated in Fig. 1. A 1 × 2 inch piece of mica was used as a stability sheet, with the thermocouple being threaded through it. These wires were insulated to within one inch of the couple junction by a woven fiber glass sleeve 1/16 inch in diameter. This whole assembly was flat, with the mica being placed in the blow mold joint and held by the mold closing. For measurements along the outer seam[b], the thermocouple wires extended only an inch or so beyond the mica assembly. For measurements at right angles to the seams, the thermocouple wires extended a sufficient distance so as to reach this position on the particular bottle in question. In this case the thermocouple wires were bent to follow roughly the appropriate contour of the mold. For measurements along the inner seams[b], the lengths of wires beyond the mica piece were several inches long and were bent in a semicircular section to go around the inside of the mold cavity to the positions desired. Thus, by using this basic assembly with different extensions of thermocouple beyond the piece of mica, it was found possible to cover any portion of the glass bottle surface. The placement of the wire just as the blow mold closed required considerable skill, but after some trials the results were usually successful. Over the years the method became even simpler, in that twisted fiber-insulated wires gave sufficient stiffness for replacement of mica. All that was needed was slight rigidity to place the wire as the mold closed.

The bare 28-gauge chromel-alumel couple was insulated, as indicated above, to within one inch of the thermocouple junction. As the glass was blown, the couple was contacted by the glass and became partially surrounded by the surface of glass and tangent to the mold, as shown in figure 1b. The bare wire carries enough oxide so that no shorting of the emf occurs by contact with the mold, which is also usually covered with some oxide. The couple wires were heated to 1400°F before insertion by passing 4 amperes current directly through the wires (see Section 2.4). This decreased the lag of measurement.

Conditions for isothermal placement of the wires were thus met as closely as the situation allowed. Heavier gauge wire was too stiff and buried itself within the glass, making it useless for surface estimation.

The thermocouple junction was welded by flattening the ends of the two wires, giving a shape like the end of a chisel. Both ends were then slightly overlapped over a spot-welding ⅛ inch diameter tip. A very slight weld was made. No bead resulted. The diameter of the tip was only slightly greater than that of the wire itself. The actual physical setup for glass temperatures included a grouping of wires (two thermocouple leads and two electrical leads—see Section 2.4) placed on the machine floor around the machine, so that after the couple was placed within the blow mold, this whole grouping of wires was carried around by the machine rotation to the position where the bottle was discharged from the machine. The couple, being heat-sealed to the bottle,

stayed with the bottle, which was caught by hand or progressed as far through the handling machines as the attached wires would allow. Obviously, many wires were broken by accidents occasioned as the machine rotated. For glass temperatures it is obvious that no connections were made with the machine, and thus the machines could be in commercial production. The only loss was the actual bottle which was measured. As has been mentioned, considerable skill was acquired in placing the thermocouples within the mold and close to the desired positions of measurement. Daily runs with two people included 40—75 single recordings.

Several runs were averaged for each location on the bottle. The individual runs were usually within 20—40°F of the average. (See Section 3.2.)

2.3. Mold Temperature Method

A consideration of thermoelectric effects tells that the insertion of a third metal within a thermocouple junction does not alter the reading if there is no temperature difference between the two junctions thus formed. That is, the insertion of an iron-mold between an iron-constantan junction, thus forming two junctions, an iron-iron-mold and a new iron-mold-constantan junction, does not alter the original reading if both temperatures are the same. If there is a temperature difference, then the reading will be between those of the two junctions provided one thermoelement is positive and one is negative to the third (or inserted) metal. In the experiments, the mold metal itself completes the circuit, and due to the closeness of the two separate junctions the temperature gradient is small. Once again please refer to Sosman[7].

Figure 2 shows the general scheme of thermocouple insertion in molds. A 3/16 inch hole is drilled to within 1/16 inch of the inside surface with a flat bottom drill. Two such holes are located within ½ inch of each other. A No. 65 drill (0.035 inch) completes the hole to the inside of the mold. Iron-constantan thermocouple wires of 20 gauge (0.032 inch) with asbestos or fiber glass insulation are used. The wire is pulled through the hole, thus compacting the insulation in the bottom of the hole. The wire is cut off flush with the inside mold surface and spot welded in place with a carbon arc, using 12 to 15 volts in several spots around the mold-wire periphery. The hole is appropriately packed and sealed for strength. This method produces a slight roughness of the mold surface. The depth of weld is not known, but repeated measurements show this factor to be consistent. The oxide coating on the wire prevents shorting behind the spot-welded junction.

It was impractical to mount the lead wires within an isothermal plane. However, the conduction back along the wires is probably small compared to the heat replacement along the mold surface due to the high thermal conductivity. Then again, the presence of the hole produces some increase of temperature due just to removal of metal. In any case, the "pros and cons" of this type of measurement are recognized and the data are as accurate as it is possible to get in a commercial installation. (See Fig. 2.)

In some instances thermocouples were imbedded within a hole drilled to within specific distances from the inside surface. Care was taken to have a small junction and to make it contact the mold metal at the bottom of the hole. The big question here is the duplication of this contact from one situation to the next. The technique of welding the wires to the bottom of the hole is to be recommended and has since been used[4].

For outside surface temperatures, the surface of the mold was drilled and tapped to about ¼ inch depth. The thermocouple junction was held under the head of a small screw. Here there is a compromise between heat to the thermocouple bead and protection against heat loss by the screw head. The procedure gives good thermal contact, but the bead is not totally free to radiate or be cooled by exterior influences. The assembly gave good mechanical strength.

2.4. Recording the Temperatures

The highest speed recorder commercially available at the time was used. It was a Tagliabue instrument with

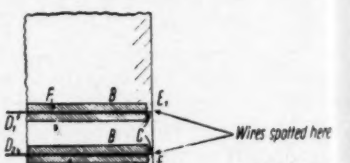


Fig. 2. Thermocouple assembly for measuring inside surface mold temperature.

A = cross-section of mold (blank or blow mold).

B = 3/16 inch holes drilled to within 1/16 inch of inside surface (use bottom drill).

C = holes drilled with Nr. 65 drill (bare thermocouple wire is pushed through and spot welded to inside surface).

D_1 = Nr. 20 gauge asbestos covered iron thermocouple wire.

D_2 = Nr. 20 gauge asbestos covered constantan thermocouple wire.

E_1, E_2 = hot junction of iron-constantan thermocouple.

F = holes filled with asbestos and sealed with cement.

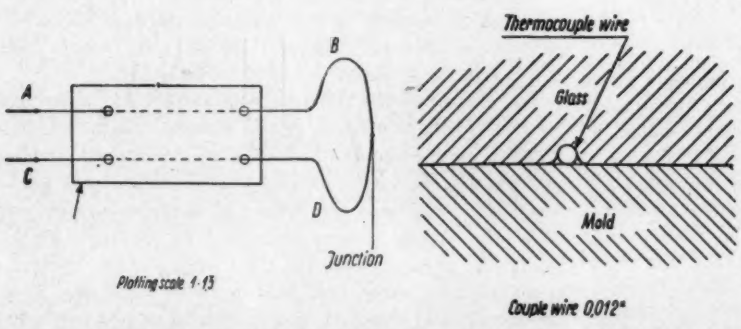


Fig. 1. The holding and relative wire immersion within the glass surface for the mica setup.

Fig. 1a. The mica support. 1 × 2 inches sheet mica with four holes through which couple wires were threaded. ⅛ inch glass wool tubing strung on wire from A to B and C to D to act as insulation from mold.

Fig. 1b. Contact condition for thermocouple wire and glass with mica setup.

a carriage travel across full scale in less than two seconds. A chart speed of one inch per five seconds was used. The instrument had internal adjustable dials which gave varying operating characteristics. It could be made to travel full scale in one step to within 20°F of balance, or any portion of full scale travel to within 20°F of balance in one step. It could be made to follow a rapidly moving temperature almost without lag. By feeding various input emf's to the recorder, it was found that it would follow changes in temperature of greater than 100°F per second with a lag of less than ½ second. It would follow faster rates at somewhat greater lags.

In glass temperature measurement it was found necessary to set these scales to follow a temperature without lag rather than to quickly jump part or full scale. Because of this the carriage was held on open circuit at a position indicating a temperature closely approximating that expected from the initial response of the thermocouple. This setting was between 1700° and 1800°F which was developed as experience progressed. Thus the first jump of the carriage was usually less than 200°F. The thermocouple was connected to the recorder at the exact instant that the thermocouple was expected to have its maximum emf. In all the glass temperature experiments the thermocouple wire was heated by electric resistance methods to a temperature where the couple recorded 1400°F. Heating to higher temperatures caused thermocouple burn-out or gave such a weak wire and junction that it was broken when contacted by the glass. The break in the resistance heating circuit and the connection to the recorder was made by a double-pole, double-throw switch at the instant the couple was expected to touch the hot glass surface—usually just after "blow-air-on" occurred. Cooling rates of such heated couples in air were determined to be approximately 300°F per second. Thus it was essential to hold the couple hot until the glass touched it.

For mold temperature measurements the thermocouple leads were connected to a mercury trough for Owens operation or to a sliding mechanical contactor for flow operation. Since many installations of multiple couples were made, connectors which carried eight to ten wires were used and interchanged as needed. These were of the radio type. There is obviously some lag in response of the recorder to the thermocouple. Its degree is not definitely known. In timing the mold cycles it was soon found that the breaks in the curves—such as when the glass left the metal—did not show any visible lag. Response on the recorder was as close to the visual cycle as could be determined by stop-watch methods. This does not mean that there is no lag in measurement. The true peak response of any couple was probably not measured. However, the data are comparative from this viewpoint.

3. Glass Temperature Data

3.1. Preliminary Considerations

In the introduction, mention was made of the consistency of glass temperatures as the glass is fed to the machine and as it is formed on the machine. The two basic processes, Owens and feeder flow, utilize incoming glass of somewhat different temperatures. In both cases the common methods of indicating glass temperatures (in the revolving pot or in the feeder spout) do not accurately measure the glass temperature at the instant it charges to the blank mold. The injection of a thermo-

Table 1

GLASS TEMPERATURES ON 12-OZ. CAPACITY FLINT BEER, OWENS OPERATION (POT TEMPERATURE 2300°F)

	Temperature °F										
	After Blow Air Is Applied		Neck Ring		5 Sec. After	Hesitation			Reheat		
Position* inches	1 Sec.	2 Sec.	Open	Delivery	Delivery	Time (Seconds)	Temp.	From (Seconds)	To (Seconds)	Temp.	Start Cooling (Seconds)
Front Seam											
¼ - ¾	1660	1590	1520	1300	1300	22 - 45	1300		No reheat		45
1 - 1½	1650	1565	1500	1310	1310	21 - 46	1310		"		46
1¾ - 2	1675	1610	1535	1240	1230	22 - 40	1230		"		40
3 - 3⅛	1580	1465	1390	1235	1230	22 - 40	1230		"		40
5 - 5¼	1660	1540	1435	1155	1125	23 - 25	1135		"		25
5¾ - 6	1625	1500	1360	1055	1050	22 - 36	1050		"		36
7¾ - 8	1590	1460	1365	1185	1170	23 - 26	1175		"		26
90° to Seams											
½ - ¾	1685	1600	1520	1325	1325	20 - 39	1325		"		39
1¼ - 1⅝	1680	1600	1525	1330	1330	21 - 40	1330		"		40
2¼ - 2¾	1680	1590	1495	1295	1295	20 - 32	1295		"		32
3¼ - 3¾	1650	1545	1460	1270	1265	23 - 28	1265		"		28
Inner Seam											
¼	1680	1585	1500	1315	1315	18 - 40	1315		"		40
⅝ - 1⅛	1690	1610	1525	1290	1290	22 - 31	1290		"		31
2 - 2¼	1650	1565	1490	1245	1245	22 - 33	1245		"		33
2⅞ - 3¼	1660	1550	1475	1220	1220	22 - 30	1220		"		30
3⅞ - 4½	1630	1555	1490	1215	1215	22 - 27	1215		"		27
4⅞ - 5	1620	1510	1410	1190	1145	None			"		
5¼ - 6	1615	1495	1390	1170	1125	None			"		
7¼ - 8¼	1605	1500	1420	1215	1175	None			"		
Bottom†											
½ - 1	1690	1590	1485	1310	1375	18 - 23	1310	23	28	1395	48

* Inches up from bottom of bottle.
† Inches in from heel.

couple into the molten mass at the appropriate time does produce good results. In the Owens revolving pot, the thermocouple can be inserted into the active glass gathering area at the appropriate depth of gathering. Such data indicate a range of actual glass temperatures from approximately 2280 to 1920°F. These conform to log viscosity of 2.7 to 3.8 and to weights of 1 to 120 oz. For the ordinary range of ware in weights of 5 to 15 oz. the viscosity range is log 2.9 to 3.2. However, any specific glass weight can be gathered over a range of viscosity—for instance, a 15 oz. weight can be gathered from log 3 to log 3.4, or a spread of plus or minus 60—65°F. Such variations are due to variation in nose diameter and length of blank cavities, amount of vacuum, thickness of glass in the finish, etc.

In the Miller press-and-blow machine, the gob can be rather stubby. When a 22-gauge thermocouple is inserted into the gob as it issues from the orifice, the maximum temperature is attained at about the time the gob delivers to the blank mold. These temperatures vary from 1865 to 1955°F. for a range of 6 to 16 oz. weight gobs. This conforms to log viscosity of 3.7 to 4.1, with an average of 3.8. These, one must remember, are thermocouple measurements, not the optical used commonly for recording gobs just as they form. Throughout this paper, thermocouple measurements only are reported.

Some early measurements on the surface temperature of parisons on the Owens machine were made by use of a compensated thermocouple assembly[6] by K. M. Henry and the senior author[c]. The hottest spot on a 12½ oz. weight catsup bottle, about 1½ inch above the bottom, was selected for these measurements. In the compensated assembly the temperature is measured at the instant of contact of glass and thermocouple head by a differential

c. The assembly was somewhat different in dimension from that suggested in the reference.

Table 2

GLASS TEMPERATURES ON 12 OZ. CAPACITY AMBER BEER, OWENS OPERATION (POT TEMPERATURE 2270°F)

	Temperature °F											
	After Blow Air Is Applied[1]				5 Sec.	Hesitation			Reheat			
Position[5]	1 Sec.	2 Sec.	Neck Ring Open	De-liv-ery	After Deliv-ery	Time (Seconds)	Temp.	From (Seconds)	To (Seconds)	Temp.	Other Notes	Start Cooling (Seconds)
Front Seam												
½ - ⅜	1620	1450	1290	1285	1300	14-16	1265	16	18	1285	See note[2]	39
1 - 1½	1620	1465	1300	1320	1320	14-15	1260	15	18	1320		36
1¾ - 2¼	1560	1360	1200	1115	1140	14-18	1175	24	27	1145	See note[3]	43
5½ - 5⅝	1640	1500	1275	1160	1145	14-17	1220	2nd hesitation			1145° from 23-27 sec.	27
6¼ - 7¼	1550	1375	1225	1110	1110	14-17	1205	"	"		1110° " 27-30 "	30
7¾ - 8⅛	1575	1390	1225	1115	1100	14-16	1210	"	"		1105° " 22-26 "	26
90° to Seams												
⅛ - ⅝	1640	1475	1260	1240	1265	14-21	1240	21	25	1265		41
1⅞ - 2¼	1640	1510	1325	1200	1210	15-19	1245	2nd hesitation			1200° from 21-24 sec.[4]	37
2⅜ - 3⅛	1610	1450	1260	1200	1195	14-21	1215	"	"		1195° " 22-31 "	31
5 - 5⅜	1625	1485	1310	1185	1145	15-17	1240					17
8 - 8½	1590	1440	1280	1145	1165	14-16	1250	"	"		1165° " 22-28 "	28
Inner Seam												
¼ - ⅜	1640	1510	1340	1265	1265	15-34	1265					34
1⅜ - 1¾	1650	1510	1360	1235	1230	14-15	1340	"	"		1130° " 22-38 "	38
3½ - 4⅜	1650	1525	1295	1220	1220	14-32	1220					32
4½ - 5	1575	1420	1220	1110	1110	21-27	1110	Sl. hesitation between 14-17 sec.				27
7½ - 8	1590	1450	1290	1145	1110	None						
Bottom[6]												
½ - ¾	1675	1560	1415	1285	1355	17-22	1285	22	28	1365		40

1. Amber cools so rapidly that temperatures at 1 sec. are much less reliable than similar data on flint.
2. Reheat to 1300° follows first reheat at 24-25 sec.
3. Reheat to 1145° follows 2nd hesitation at 21-24 sec.
4. Slight reheat from 24-26 sec. to 1210°.
5. Inches up from bottom of bottle.
6. Inches in from heel.

Table 3

VISCOSITY COMPARISONS, 12 OZ. BEER, FLINT AND AMBER GLASS, OWENS OPERATION

		Flint			Amber		
Condition	Time in Cycle	Temp., °F	Log Viscosity	Viscosity Units	Temp., °F	Log Viscosity	Viscosity Units
Side Wall — Average	1 sec. after blow air applied	1640	5.16	145,000	1610	5.10	126,000
" " — Average	2 sec. " " " "	1540	5.84	700,000	1460	6.48	3,000,000
" " — Coldest	2 sec. " " " "	1465	6.44	2,800,000	1360	7.00	10,000,000
" " — Average	Neck ring opening	1360	7.4	25,000,000	1280	7.8	63,000,000
" " — Hottest	" " "	1535	5.88	760,000	1360	7.00	10,000,000
" " — Hottest	Delivery	1330	7.7	50,000,000	1320	7.38	24,000,000
Bottom — Average	Neck ring opening	1485	6.28	1,900,000	1415	6.5	3,200,000
" — Average	Delivery	1310	7.9	80,000,000	1285	7.76	58,000,000

thermocouple which ascertains that the couple head is preheated to the same temperature as the glass it contacts. There is no heat flow in either direction at this instant and the method is a reliable but tedious one for precise surface temperature measurement. It must not be confused with the normal contact pyrometer, which depends upon heat flow from the hot surface and is only useful—and then not too accurate—on a high conductivity material such as a metal. The reader is referred to Ref. 6 for the fundamentals of compensated assemblies.

The results of several such measurements on the 14 oz. capacity catsup bottle all fell within the range of 1740 to 1780°F, or log viscosity 4.4 to 4.5. This was then the hottest temperature on the bottle surface at the instant the surface was blown out to the mold. The later glass temperature data were consistent with these measurements.

As the studies progressed there was considerable thought given to the end of the working range from the viscosity viewpoint. An early concept considered the fact that the glass was last worked (moved) during the blowing cycle. The above compensated thermocouple measurements were made with this viewpoint in mind. Soon, however, a more practical approach was taken based on deformation after the bottle was delivered from the mold. If deformation occurred after delivery, then the glass surface was not viscous enough to hold the shape. Therefore the definition became: "The lower end of the working range conforms to the maximum temperature of the glass surface, at any portion of the bottle, to which the surface must be cooled to avoid deformation of the bottle upon discharge from the machine."

The attitude on this definition developed from a practical consideration of the limitations of machine speed. This is often set by the bottle deformation—or bottle delivery at too high a temperature.

The definition obviously requires a change of working range for different shapes. A flat shape would distort more easily than a round. Greater thickness would cause distortion due to more heat storage and more surface reheat after delivery from the mold. A press-and-blow process would give different results than a blow-and-blow process. The lower end of the working range is a function of wall thickness, wall shape, as well as surface temperatures, and temperature gradient.

The next section discusses the determination of glass surface temperatures by the methods described in Section 2.2.

3.2. Some Typical Individual Glass Temperature Measurements on Owens Machines

As has been indicated, average curves were determined for several runs at each location. Some idea of the

Table 4

GLASS TEMPERATURES ON HALF-GALLON JUG, OWENS OPERATION (POT TEMPERATURE 2140°F)

		Temperature °F			
Position	Height from Bottom, Inches	2 Sec. After Blow (18 Sec.)	Neck Ring Open (22 Sec.)	Delivery (36 Sec.)	Into-Lehr (51.0 Sec.)
Front seam	⅛*	1400	1315	1355	1275
	¾*	1495	1310	1135	1065
	7¼	1520	1280	1130	1035
	5½	1470	1240	1110	1015
	4	1515	1290	1135	1000
	2¼	1500	1250	1095	1025
	¾	1475	1285	1190	1155
90° to seams	6	1625	1355	1115	985
	4½	1500	1300	1115	975
	2	1510	1300	1110	1010
Rear Seam	6¼	1545	1330	1115	1005
	4¾	1575	1335	1135	1020
	3	1615	1370	1155	1060
	1¾	1560	1330	1145	1105

* Distance down from parting line.

Table 5

GLASS TEMPERATURES ON 10¾ OZ. CAPACITY MUSTARD, MILLER OPERATION (GOB TEMPERATURE 1920°F)

		Temperature °F						
	1st Blow Release	2nd Blow		3rd Blow			5 sec. after	
Position*	Pressure	On	Off	On	Off	Delivery	Delivery	Into Lehr
Front Seam								
3¼	1670	1590	1535	1480	1440	1320	1270	1185
2⅜	1625	1535	1485	1435	1405	1300	1270	1205
1⅝	1660	1590	1550	1515	1490	1390	1320	1245
1¼	1605	1535	1495	1455	1430	1345	1305	1240
⅜	1665	1615	1585	1550	1525	1385	1265	1120
90° to Seams								
3¾	1575	1505	1475	1440	1420	1310	1250	1160
2½	1590	1540	1505	1470	1445	1335	1260	1170
1⅜	1595	1535	1500	1460	1440	1335	1270	1190
1¼	1550	1490	1460	1430	1410	1345	1270	1210
½	1600	1545	1520	1490	1470	1380	1280	1110
Inner Seam								
3¼	1610	1520	1465	1415	1385	1300	1265	1185
2	1605	1550	1515	1470	1445	1340	1310	1230
1¼	1535	1480	1450	1415	1395	1315	1270	1185
⅜	1640	1590	1570	1545	1525	1415	1295	1120

* Inches up from bottom of bottle.

variations is necessary. Over a considerable period it was found that the variations of individual runs were affected by several conditions. Perhaps the most important was that of holding the glass out to the mold. Shapes which had varying degrees of such mold contact obviously varied more. The most notable examples were flat sides of flasks, areas in the bottom, and the hottest areas in the sidewalls. Also certain custom shapes of unusual contour gave wider results. In many instances the curves indicated the times when the glass was staying with the mold, contrasted to times when it was obviously pulling away from the mold. In the latter case one cannot average such extremes. It was just a point of operation that was evident from the curves.

Figure 3, curve A, gives four runs on the upper seam sidewall, approximately 4 inches above the bottom of an 8-oz. whiskey flask. This would be called an exceptional check during the early parts of the cycle. The points that divert most in the later part of the cycle are those farthest from the general average location—about one inch below the others on the bottle. Zero time was at cut-off—a consistent point in all plots of Owens data. Points on Fig. 3, curve B, in the middle flat sidewall of the same job, vary more and show a hesitation upon delivery of the bottle from the mold (22 seconds) (plateau in the cooling curve).

Figure 3, curve C, gives results on a position in the bottom of a 12 oz. flint beer. The plateau in the cooling curve is a common situation in the bottom or at other locations where glass pulls away from the mold. The reheat after the plateau is rather common for heavy, thick glass areas.

3.3. Glass Temperature Measurements Over an Entire Bottle Surface (12 oz. Flint Beer On Owens)

Average data for study on a 12 oz. flint beer, weight 12 oz., are given in Table 1. A plot of the front seam temperature data is given in Fig. 4. The body of the bottle is fairly uniform in temperature, although there is a consistent difference between inner[d] and outer[e] seam temperatures. The inner seam runs from 10 to 40°F hotter in the earlier portion of the cycle, with the differences increasing at delivery. After delivery the differences are somewhat less. Comparisons to amber operation will be made in section 3.4 below.

3.4. Comparison of Flint and Amber Glass Temperature 12 oz. Beer on Owens

Table 2 shows amber glass temperatures for the same 12 oz. beer reported on above. The rate of cooling of the glass surface during blowing for amber is much greater than for flint glass. Naturally, there follows a period of slower cooling after discharge from the machine, with the amber showing much hesitation or even reheat at this stage. Table 2 can be compared to Table 1. At one second after blow the amber is 20 to 100 F colder than the flint; at two seconds the difference is still greater: at neck ring opening the amber is between 1200 and 1300°F and the flint from 1360 to 1520°F. The partial equalization of temperature after delivery from interior to surface is evidenced by the breaks in cooling of amber glass at this period in the cycle. These comparisons have all been made at the front seam positions. Other positions follow similar trends.

Viscosity comparisons are also very revealing (Table 3). During the interval from one to two seconds the flint glass surface shows a viscosity change of five-fold, while the amber change is 24-fold. The ratios of viscosities from amber to flint are only about 2 or 3 to 1 later in the cycle. The practical ends of the working

d. Inner seam refers to front cavity seam nearest the mold hinge.
e. Outer seam refers to seam farthest from mold hinge.

Table 6

GLASS TEMPERATURES ON 16 OZ. CAPACITY ROUND MAYONNAISE, MILLER OPERATION (GOB TEMPERATURE 1955°F)

	Temperature °F					
	Release Pressure					
Position*	1st Blow	2nd Blow	3rd Blow	Delivery	5 sec. after Delivery	Into Lehr
Front Seam						
4	1705	1570	1485	1320	1215	1110
3	1725	1595	1480	1315	1235	1140
2¼	1720	1560	1465	1335	1255	1165
1¾	1710	1590	1480	1335	1225	1125
⅞	1705	1630	1560	1400	1245	1110
¼	1715	1635	1570	1420	1245	1135
90° to Seams						
4¼	1735	1640	1550	1355	1230	1135
3⅜	1725	1640	1565	1395	1280	1150
2¼	1750	1660	1580	1395	1225	1125
1¼	1710	1595	1525	1370	1230	1110
½	1710	1635	1570	1435	1255	1140
⅛	1725	1660	1590	1420	1245	1095
Inner Seam						
4¼	1700	1600	1515	1340	1250	1160
3½	1720	1600	1490	1325	1245	1150
2¼	1700	1600	1505	1360	1290	1200
1⅛	1700	1625	1550	1370	1240	1150
¼	1700	1590	1515	1345	1200	1055
Bottom†						
⅜	1620	1600	1575	1475	1290	1125

* Inches up from bottom of bottle.
† Inches in from heel.

range are not greatly different for amber and for flint (log 7.4 and log 7.7).

3.5. Glass Temperatures on Owens Half-Gallon Jug

In a large single-cavity half-gallon jug, the glass tem-

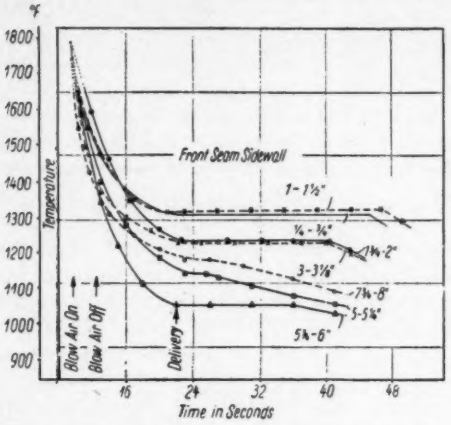


Fig. 4. Glass temperature curves for 12 oz. capacity flint beer bottle, Owens operation (distances shown are inches above bottom of bottle).

eratures (Table 4) are quite uniform at delivery except n the area close to the neck ring parting line. This rea shows very slow cooling, which indicates either oor initial glass-metal contact or a pulling of the glass way from the metal after initial contact. Horizontal radients show the inner seam to be about 50 to 100°F otter than the front seam. At delivery the glass temperatures vary from 1095 to 1145°F except for the area near the parting line.

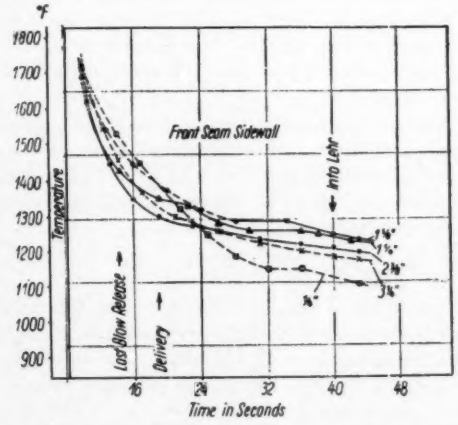


Fig. 5. Glass temperature curves for 10¾ oz. capacity mustard jar-Miller operation (distances shown are inches above bottom of bottle).

3.6. Generalizations on Owens Glass Temperatures

The general picture on glass temperatures for Owens ware of medium size, both flint and amber, can be given based on the data reported and ðn other unreported data. The following statements fall into a class of generalities (with exceptions) rather than set conclusions. The term "temperature" as here used implies surface measurements by the methods developed.

1. Owens glass temperatures during forming generally show continuously decreasing values in the neck, shoulder and adjacent upper sections of the sidewall. As one progresses into the middle sidewall areas, a cooling plateau or hesitation[f] may occur at the release of blow

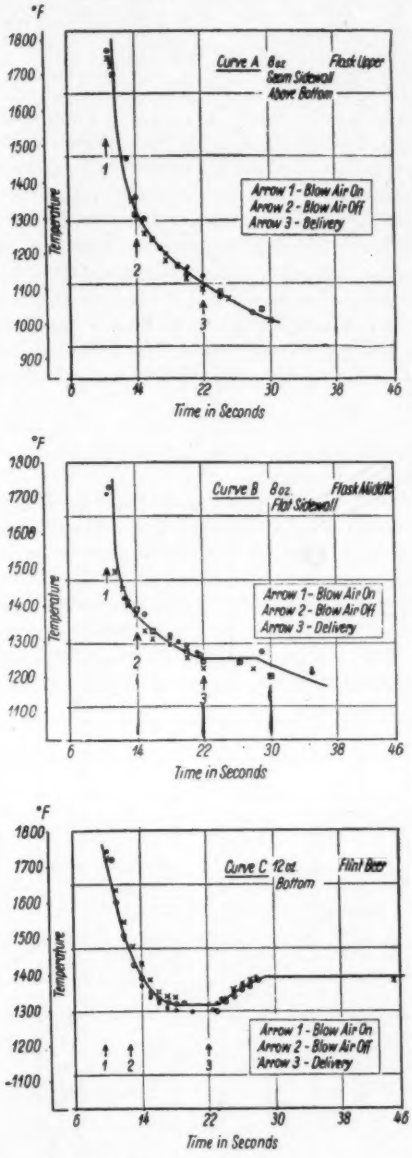


Fig. 3. Typical glass temerature curves.

air pressure or upon delivery of the bottle. The middle and lower sidewall sections usually give a plateau at release of air pressure or upon delivery. These are the portions commonly causing trouble from "out-of-shape." In these thicker areas, reheating of the surface may follow the cooling plateau. Sidewall sections just above

f. As here used, "hesitation" means zero cooling rate, or holding a specific temperature.

(*Continued on page* 113)

Cerium in the Glass Industry

by Clifford A. Hampel, CONSULTING CHEMICAL ENGINEER, SKOKIE, ILL.

● CERIUM IS THE MOST ABUNDANT and the most widely used of the rare earth elements. It is located in Group III of the periodic table (atomic weight 140.13, atomic number 58, and has two valences, +3 and +4, corresponding to the cerous and ceric states. Cerous compounds are related in properties to the other trivalent rare earth elements and to scandium, yttrium and actinium in Groups III, but ceric compounds are similar in nature to those of titanium, zirconium and thorium, Group IV elements that are also tetravalent. As will be discussed later, both types of cerium compounds are stable and easy to handle and store.

Occurrence

The principal sources of cerium are monazite, a rare earth thorium orthophosphate, either as sands present in stream and beach placer deposits or as massive monazite; and bastnasite, a fluocarbonate found in hydrothermal deposits associated with barite, fluorite and calcite. Monazite accounts for most of the cerium produced in the United States and is largely imported at present as massive material from the Union of South Africa. However, there are deposits of monazite sand available in Florida, the Carolinas and Idaho. While some of the bastnasite deposits of California are being worked, these very large deposits represent at the present time a reserve source of great importance. The United States is not a "have not" nation with respect to rare earth raw material sources.

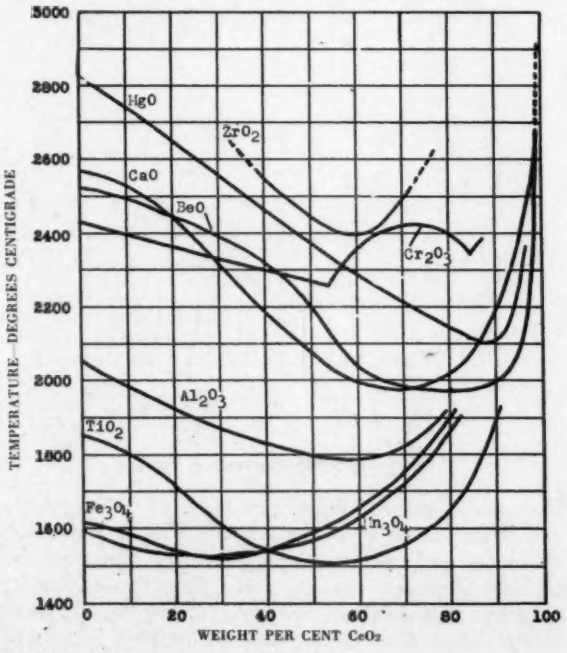


FIG. 1

Cerium oxide systems with various oxides. Adapted from literature by H.v. Wartenberg et al. (1, 2, 3, 4, 5, by Lindsay Chemical Division.)

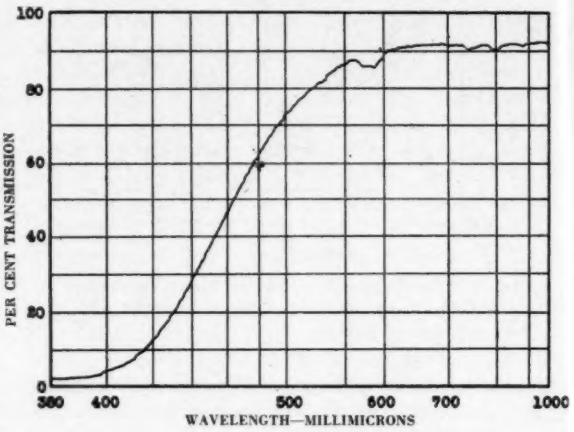


FIG. 2

Absorption spectrum of yellow titanium cerate glass. The specimen contained 1.2 per cent CeO_2 and was 6 mm. thick, polished on both surfaces. Not corrected for reflection loss. Measured on a Beckman DK-2 recording spectrophotometer.

In these ores the cerium content is about one-half of the total rare earth content, expressed as oxides, and amounts to some 30 per cent Ce_2O_3 in Idaho monazite concentrates and up to 47 per cent in California bastnasite concentrates.

Cerium Products

Cerium products produced by the extraction and separation methods described in a previous article* are used in the glass industry in two forms, i. e., as mixtures with other rare earth compounds and as more-or-less pure cerium compounds.

The rare earth salts, including the oxides and hydrates, are the materials first separated after thorium has been removed from the original raw material. The types and composition are given in Table I. All are commercially available products. As a class they are economical sources of cerium compounds and can be used industrially when the content of the other rare earths does not interfere with the specific application.

Cerium compounds of several types are available as

* THE GLASS INDUSTRY, *41*, (1960) p. 14.

"commercial" and high-purity grades. Table II lists the compounds, typical analyses, formulas and some data on form and solubility. In the oxide, hydrate, ammonium nitrate and ammonium sulfate, cerium is tetravalent, and in the other compounds it is trivalent.

Cerium Oxide Properties

Cerium oxide is the chief compound used in the glass industry, as ceric oxide, CeO_2, or hydrated ceric oxide, $CeO_2.xH_2O$; as the decomposition product of a cerium salt; or as contained in the rare earth salt mixture resulting from the high temperature of the glass furnace.

There are two recognized cerium oxides: cerous oxide, Ce_2O_3, which is unstable in air and is oxidized exothermically to CeO_2; and ceric oxide, CeO_2, which is the only cerium oxide commercially available. Cerous oxide is formed by the complete reduction of CeO_2 with hydrogen at elevated temperature. It is not of importance in itself, but it is formed *in situ* in some applications in glasses of various types.

Ceric oxide is formed by the ignition in air of the salts of volatile acids, most commonly by calcining cerous or ceric hydroxide, cerous oxalate, cerous carbonate, cerous nitrate, basic ceric nitrates or sulfates, and ceric ammonium nitrate. It shows colors ranging from pure white to dark brown, most commonly a light brown or tan. When pure, the oxide has a cream to yellow color. The brown color is due to small amounts of other rare earths, chiefly praseodymium oxide which forms a black oxide, Pr_6O_{11}. Particle size, ignition temperature, type of salt ignited and purity of the preparation affect the color of ceric oxide.

Ceric oxide is a refractory oxide quite insoluble in acids. It is slowly attacked by prolonged heating in nitric, sulfuric or hydrochloric acids. With sulfuric acid yellow ceric sulfate, insoluble in H_2O_4, is formed, and with hydrochloric acid the solution contains cerous chloride, since ceric chloride is reduced by chloride ion with the liberation of chlorine.

Ceric compounds are strong oxidizing agents, and in turn are easily reduced by such reagents as halogen acids, hydrogen sulfide, sulfurous acid, hydrogen peroxide in acid solutions, ferrous salts and oxalic acid. This property accounts for the valuable decolorizing action of cerium compounds in glass compositions.

Physical properties of ceric oxide are listed in Table III.

Table I

COMMERCIAL RARE EARTH SALTS

Rare Earth Salt	Formula	Color and Form	Solubility Water	Solubility Acids
Sodium Sulfate	$RE_2(SO_4)_3 \cdot Na_2SO_4$	Pink crystals	SS	SS
Hydrate	Hydrated RE oxide	Yellow powder	I	S
Carbonate	$RE_2(CO_3)_3 \cdot xH_2O$	Fine pink powder	I	S
Oxide	$RE_2O_3 + CeO_2$	Brown powder	I	S
Chloride	$RECl_3 \cdot 6H_2O$	Lumps or cast	VS	S
Acetate	$RE(C_2H_3O_2)_3 \cdot xH_2O$	Pink powder	S	S
Fluoride	$REF_3 \cdot 0\text{-}1H_2O$	Powder	I	I
Oxalate	$RE_2(C_2O_4)_3 \cdot xH_2O$	Pink powder	I	SS

I = insoluble, SS = slightly soluble, S = soluble, VS = very soluble, RE = rare earths

APPROXIMATE COMPOSITION OF THE CONTAINED RARE EARTH OXIDE IN THESE MATERIALS

	per cent		per cent
Lanthanum oxide, La_2O_3	24	Samarium oxide, Sm_2O_3	3
Cerium oxide, CeO_2	48	Gadolinium oxide, Gd_2O_3	2
			(approx.)
Praseodymium oxide, Pr_6O_{11}	5	Yttrium oxide, Y_2O_3	0.2
			(approx.)
Neodymium oxide, Nd_2O_3	17	Other rare earth oxides	0.8
			(approx.)
			100

Table I (continued)

TYPICAL ANALYSES, PER CENT

	Rare Earth Sodium Sulfate	Rare Earth Hydrate	Rare Earth Carbonate	Rare Earth Oxide		Rare Earth Chloride	Rare Earth Acetate	Rare Earth Fluoride	Rare Earth Oxalate
CeO_2	20.6	37.4	31.2	45.6	43.6	22.0	17.8	38.4	22.6
La_2O_3	10.3	18.7	15.6	22.8	21.8	11.0	8.8	19.2	11.2
Nd_2O_3	7.3	13.3	11.0	16.2	15.6	7.8	6.3	13.6	8.0
Pr_6O_{11}	2.2	3.9	3.3	4.7	4.6	2.3	1.9	4.0	2.4
Sm_2O_3	1.3	2.3	2.0	2.8	2.7	1.4	1.1	2.4	1.4
Gd_2O_3	0.9	1.6	1.3	1.9	1.8	1.0	0.7	1.6	0.9
Y_2O_3	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.2	0.1
Other REO	0.3	0.6	0.5	0.8	0.7	0.4	0.3	0.6	0.4
Total REO (min.)	43	78	65	95	91	46	37	80	47
SO_3	40-43	1-2	0.5	1-2	2-3	0.05	0.5	0.05	
P_2O_5	1	1-2	0.01	0.5	2	0.05	0.05	0.5	
Na_2O	6-9	1	0.05	0.1	1	0.5	0.05	0.5	
$CaO + MgO$	1.8	2-3	0.2	1	2-3	2	0.1	2	
Fe_2O_3	0.1					0.005			
$Fe_2O_3 + Al_2O_3$	0.2	3-4	0.1	1-2	3-4	0.1	0.05	1	
SiO_2	0.07	0.1	0.05	0.05		0.02	0.05	0.2	
Fluoride (min.)	—	—	—	—	—	—	—	26	
Acid insol.	—	0.2	nil	0-2	0.3	0.5	nil	—	
Water insol.	—	—	—	—	—	0.5-1	nil	—	
Moisture (105°C)	0.5	0-3	0-5	nil	nil	—	—	nil	
" (105-200°C)	1	5	—	nil	nil	—	—	nil	
LOI ("as is")	—	11-16	30-35	0-1	0-1	—	—	—	53
Valence of cerium	3	4	3	4	4	3	3	3	3

LOI = loss on ignition REO = rare earth oxide

Typical Analyses
(all data in per cent)

Cerium Salt	Purity*	CeO_2	Di_2O_3†	Fe_2O_3	CaO	MgO	P_2O_5
Hydrate	94-97	83 min.	2.5 A	0.2 A			1.5 A
	94-97	83 min.	2.5 A	0.1 A			0.5 A
	99.9+	83 min.	0.04 max.	0.05 A			tr A
Oxide	94-97	90 min.	3-5 A	0.1 A			0.5 A
	99.9+	99.5 min.	0.05 max.	0.003 A			0.005 A
Oxalate	99.9+	50 min.	0.025 max.	0.002 A	tr A	0.05 A	
Chloride	99.9+	45 min.	0.025 max.				
Fluoride	94-97	78 min.	2 A				
	99.9+	79 min.	0.04 max.				
Nitrate	99.9+	39 min.	0.02 max.	0.003 A	0.1A	0.1 A	0.005 A
Ammonium Nitrate	94-97	28 min.	0.3 A	0.1 A			
Ammonium Sulfate	94-97	23 min.	0.3 A	0.1 A			

* Expressed as % CeO_2 in the contained rare earth oxide
† Didymium oxide = other rare earth oxides
I = insoluble, SC = soluble strong or concentrated mineral acids.
SS = slightly soluble, S = soluble, tr = trace, A = approximate

Table II

CERIUM SALTS

Cerium Salt	Formula	Color and Form	Solubility: Water	Solubility: Acids
Ceric Hydrate	$CeO_2 \cdot xH_2O$	Yellow powder	I	SC
Ceric Oxide	CeO_2	Flesh powder	I	SC
Cerous Oxalate	$Ce_2(C_2O_4)_3 \cdot xH_2O$	White powder	I	SS
Cerous Chloride	$CeCl_3 \cdot 6—7H_2O$	White-yellow lumps	S	S
Cerous Fluoride	$CeF_3 \cdot 0—1H_2O$	White powder	I	I
Cerous Nitrate	$Ce(NO_3)_3 \cdot 6H_2O$	White crystals	S	S
Ceric Ammonium Nitrate	$(NH_4)_2Ce(NO_3)_6$	Yellow crystals	S	S
Ceric Ammonium Sulfate	$(NH_4)_2Ce(SO_4)_3 \cdot 2H_2O$	Yellow crystals	S	S

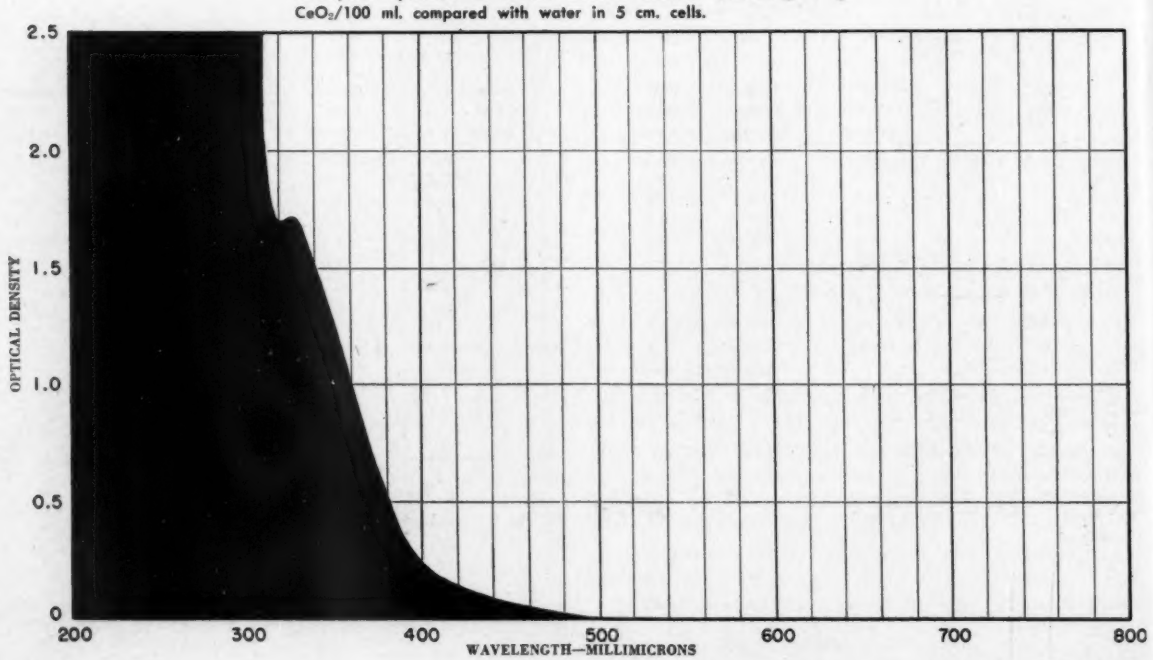
Table II (cont.)

APPROXIMATE COMPOSITION OF OTHER RARE EARTH (DIDYMIUM) OXIDES CONTAINED IN THE CERIUM SALTS

Lanthanum oxide, La_2O_3	45-46%	Gadolinium oxide, Gd_2O_3	3-4%
Praseodymium oxide, Pr_6O_{11}	9-10	Yttrium oxide Y_2O_3	0.4
Neodymium oxide, Nd_2O_3	32-33	Other rare earth oxides	1-2
Samarium oxide, Sm_2O_3	5-6		100

FIG. 3

Absorption spectrum of cerous chloride solution containing 1 g. CeO_2/100 ml. compared with water in 5 cm. cells.



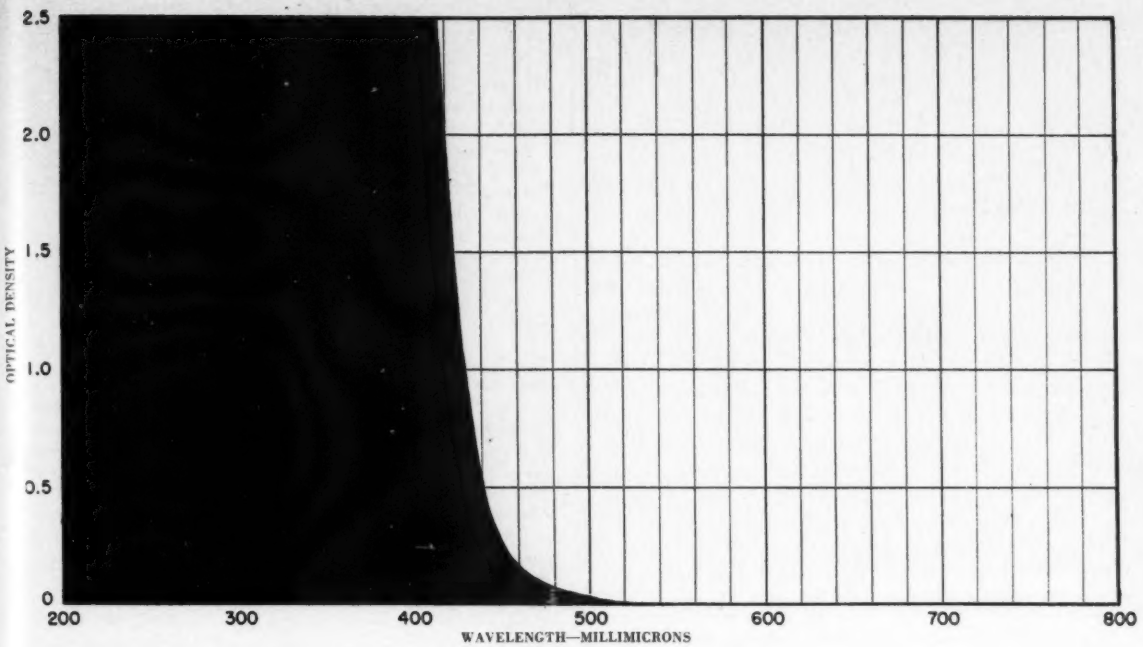


FIG. 4

Absorption spectrum of ceric ammonium nitrate solution containing 1 g. CeO_2/100 ml. compared with water in 5 cm. cells.

Cerium Hydrates. In many applications, especially in the glass industry, cerium hydrate can be substituted with economy for cerium oxide. Cerium hydrates of varying degrees of purity containing 83 per cent CeO_2 minimum are available commercially. They are hydrated ceric oxides whose composition varies from $CeO_2.\frac{1}{2}$ to $2H_2O$. All are yellow in color. At elevated temperatures the water of hydration is lost. They are made by treating cerous or ceric salt solutions with alkali hydroxides, or by direct conversion of insoluble cerium compounds in boiling strong alkali hydroxides. When the precipitated cerium hydroxides are dried, part of the water is lost and any cerous cerium present is oxidized to the ceric state by the air.

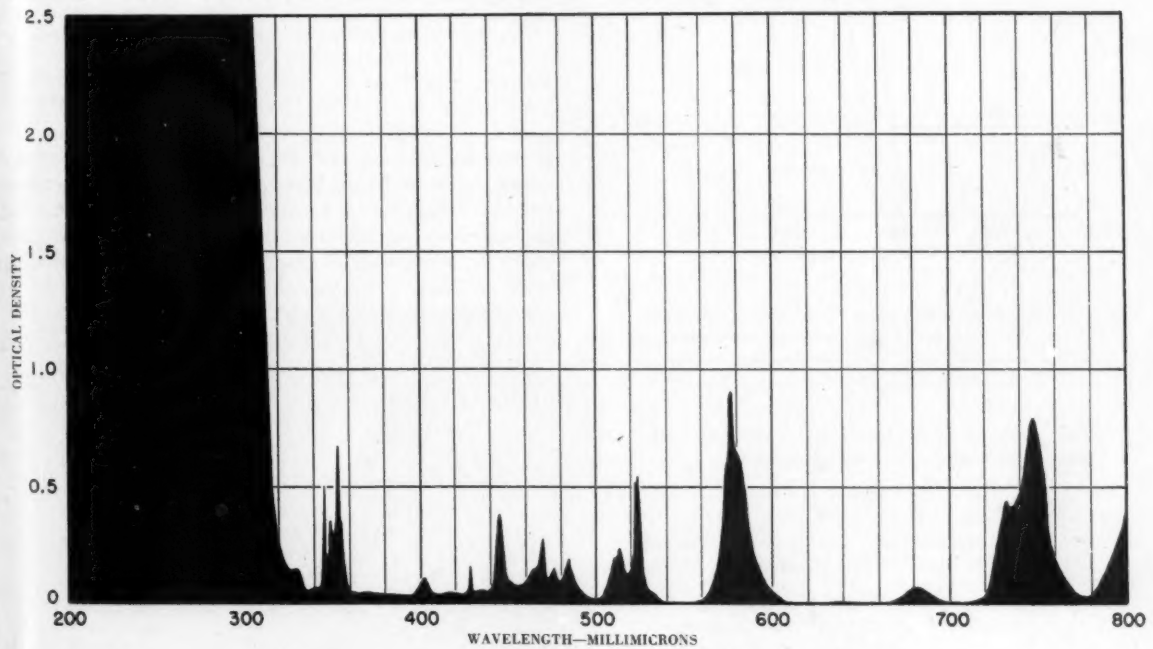


FIG. 5

Absorption spectrum of mixed rare earth chloride solution from monazite containing 2 g. rare earth oxide/100 ml. compared with water in 5 cm. cells.

Oxide Systems. Figure 1 summarizes the binary phase diagrams of the CeO_2 systems with MgO, CaO, BeO, ZrO_2, Cr_2O_3, Al_2O_3, TiO_2, Fe_3O_4 and Mn_3O_4 from the data of H.v. Wartenberg et al[1, 2, 3, 4, 5]. Data on the CeO_2-Cr_2O_3 system are given by Veil[6]; on the CeO_2-ThO_2, CeO_2-ZrO_2 and CeO_2-HfO_2 systems by Passcrini[7]; on the CeO_2-UO_2 system by several investigators[8, 9]; and on the CeO_2-U_3O_8 system by Ruderoff and Valet[8].

Rare Earth Sodium Sulfate. This material, having the formula $RE_2(SO_4)_3.Na_2SO_4.2H_2O$, where RE represents the rare earth content, is the most economical source of cerium oxide and can be used in many of the glass industry applications of cerium. Its typical analysis is given in Table I. A light pink crystalline powder, it is sparingly soluble in water and acids. The pink color is due to the neodymium present in it. The combined water content is 4.8 per cent maximum, based upon a molecular weight of 746 (the average molecular weight of the rare earth elements comprising it is 140), and it loses one per cent water at 105°C. In fact, some of the combined water of hydration is lost in drying. The bulk density of the material is 1.9 g/cc and its angle of repose is 35°.

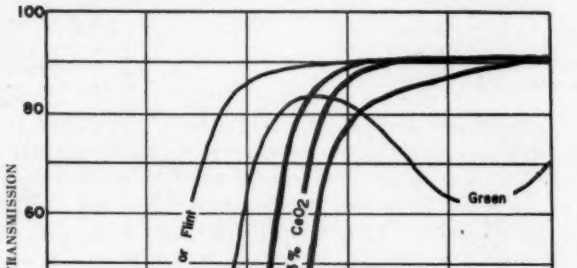


FIG. 6

Ultraviolet absorption spectra for colorless glasses containing cerium compared with flint, green, and amber bottle glasses. Polished specimens 2 mm. thick measured against air. Not corrected for reflection loss. The cerium glasses contain 1.5, 3, and 4 per cent CeO_2.

When heated in the air rare earth sodium sulfate undergoes the following sequence of reactions:

Table IV

TEMP., °C	
150- 200	Loss of combined water according to the equation: $RE_2(SO_4)_3 \cdot Na_2SO_4 \cdot 2H_2O \rightarrow RE_2(SO_4)_3 \cdot Na_2SO_4 + 2H_2O$
200- 860	No further changes
860- 960	Becomes sticky because of sodium sulfate liquid formation: $RE_2(SO_4)_3 \cdot Na_2SO_4 \rightarrow RE_2(SO_4)_3$ (s) + Na_2SO_4 (l)
960-1030	Decomposition completed, leaving a sticky residue: $RE_2(SO_4)_3$ (s) $\rightarrow RE_2O_3 + 3SO_3$; $2Ce_2O_3 + O_2 \rightarrow 4CeO_2$, or $Ce_2O_3 + SO_3 \rightarrow 2CeO_2 + SO_2$

All of the other oxides of the rare earths present remain in the trivalent state, with the exception of praseodymium, which forms an oxide having the formula, Pr_6O_{11}; and terbium, which forms an oxide of formula, Tb_4O_7. The approximate composition of the oxides obtained from the above decomposition of rare earth sodium sulfate is that given in Table 1 for the contained rare earth oxides in rare earth salts.

Table III

PHYSICAL PROPERTIES OF CERIUM OXIDE

Molecular weight of Ce_2	172.13
Molecular weight of Ce_2O_3	328.26
Melting point of CeO_2 (tends to lose oxygen and form Ce_2O_3 at high temp.)	over 2600°C
Melting point of Ce_2O_3	1692°C
Temperature of vaporization (compared with 1900°C for MgO and 1750°C for BeO)	1875°C
Hardness (Moh's scale)	6
Crystal structure: Cubic, fluorite type Cl, space group Fm3m, 4 molecules per unit cell, a = 5.402 Å. No transition on heating.	
Density: apparent	5 g/cc
true	7.3 g/cc
Porosity of compressed powder	32-40%
Refractive index	2.2-2.3
ΔH_{298}	—233 kcal/mole
ΔF_{298}	—232 kcal/mole
ΔS_{298}	28.2 cal/°C/mole
Cp_{298}	15.1 cal/°C/mole
Heat capacity (273-373°K)	15.1
Coefficient of thermal expansion: (85 + 0.55T) (10^{-7}) per °C, where T = 0-1000°C	
Heat of diffusion in W	83 x 10^3 g-cal
Diffusibility in W	95 x 10^{-11} cm^2/sec
Resistivity CeO_2	5 x 10^7 ohm-cm
in air or vacuum at 500°C	5 x 10^7 ohm-cm
in air at 1200°C	240 ohm-cm
in vacuum at 1200°C	65 ohm-cm
in oxygen at 800°C	6.5 x 10^4 ohm-cm
in oxygen at 1200°C	340 ohm-cm
in nitrogen at 800°C	2.2 x 10^4 ohm-cm
in nitrogen at 1200°C	90 ohm-cm
In the CeO_2-UO_2 system the specific resistance is lowest at 40 mole per cent CeO_2	250 ohm-cm
Resistivity Ce_2O_3	
in hydrogen at 100°C	0.13 ohm-cm
in hydrogen at 700°C	500 ohm-cm
Dielectric constant (20°C)	26
Temperature coefficient of dielectric constant (100/E/dE/dt)	0.5
Electron emission from CeO_2: electron emission is increased in ultraviolet light up to 3000 Å. Air, H_2 and O_2 decrease the photoemission. Saturation currents increase with temperature increase.	
Magnetic susceptibility	0.14 x 10^6 dyne-cm/g
	52 magnetons/mole

CERIUM IN GLASS MANUFACTURING

Cerium products, chiefly the oxide, are used in four general categories of application in the glass industry:

1. Polishing
2. Decolorizing
3. Coloring
4. Ultraviolet and other radiation-stable glass

Polishing

The most important use for cerium oxide is in glass polishing, where it is replacing rouge as a superior polishing agent. This use was developed in Europe in the

(*Continued on page* 109)

Ultrasonic Cleaning for Glass Processor

● WHERE CONVENTIONAL CLEANING methods are slow or expensive, ultrasonic equipment often supplies the answer. Advantages of ultrasonic cleaning are its rigorous and thorough scrubbing action, speed, and ability to get into hard-to-reach areas.

Hodes-Lange Corporation (North Bergen, N.J.), for example, has found that, with ultrasonic equipment included in a compact production line machine, it is possible to process more than 80,000 ampules a day, untouched by the operator.

Funnel-topped glass ampules, picked from a receiving hopper by an endless conveyor belt, are suspended by their funnels, open end up. A batch of 12 ampules is carried over the cleaning tank and rinsed by a jet of water. The ultrasonic cleaning tank simultaneously rises until the water in the tank covers the lower ¼ in. of the ampules. Ultrasonic vibrations, produced by a generator and transmitted through the glass, loosen all dirt particles from the inner walls of the ampules; the water jet removes them. After the first six-second cleaning cycle, a second ultrasonic bath followed by a final rinse with distilled or deionized water leaves the ampules chemically clean.

Dried ampules are sterilized by heating them almost to the distortion point of the glass. When cooled to room temperature, they are filled, and residual air is removed by flushing with nitrogen. Sealed by flame-fusing the necks, the ampules are delivered to trays for testing and packaging, untouched from start to finish.

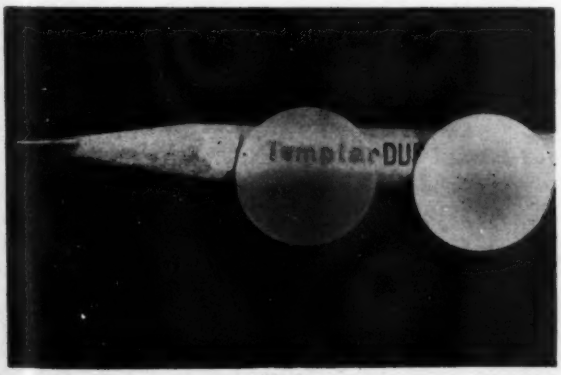


FIG. 1

Quartz crystal (right) has gone through complete cleaning process (left). Despite its thinness, crystal is not damaged by ultrasonic energy.

FIG. 2

Glass sleeves, measuring no more than ⅛ in. OD and often used in the production of electronic diodes, are cleaned by ultrasonics.

How Ultrasonic Cleaning Works

Cavitation—the rapid formation and sudden collapse of thousands of pressure cells — is a phenomenon caused by high-frequency (38 kc) mechanical vibrations in the liquid, a frequency well beyond the range of human hearing.

An ultrasonic generator, produces the electrical oscillations, which are converted into the desired mechanical vibrations by means of a ceramic transducer. These sound waves are readily coupled into each ampule via the water in which they are immersed, because glass offers very little resistance to their propagation. Resulting cavitation has been estimated to generate as much as 75,000 psi during collapse of the bubbles, more than enough to blast off any soil particles adhering to the wall. Yet, this action is so gentle that no breakage or any other physical damage is encountered.

Because no standard measure exists at the present time, it is almost impossible to define cleanliness except in terms of product quality.

Quartz crystals are often used to show how clean "really clean" actually is. Because the resonant frequency of a quartz crystal varies inversely as its thickness, and can be measured accurately to one cycle, it is theoretically possible to detect a layer of dirt one 10-billionth of an inch thick. Supposedly clean crystals are immersed in an ultrasonic bath for five seconds, and the frequency measured. The cleaning process is continued, and layer after layer of dirt is removed, until no more is left; the frequency remains constant.

A crystal-grinding firm now uses this method to clean the entire output before subjecting clean crystals to government inspection. Previously, boiling for over an hour in acid and detergent, six rinsings, and oven drying left a high percentage of rejects. Using ultrasonic cleaning equipment, cleaning time is drastically reduced, and reject rate is practically non-existent.

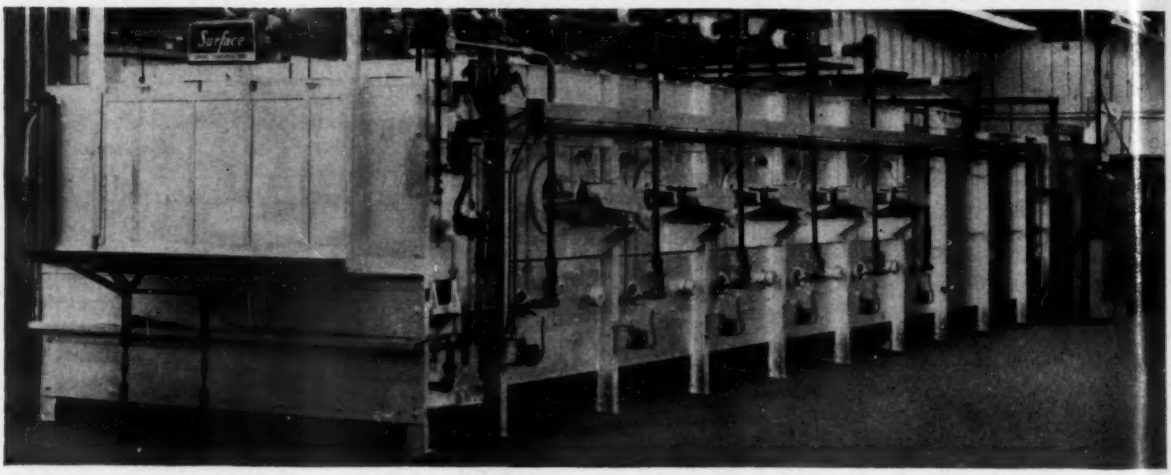
(*Continued on page* 109)

duplicate cycles with precision in modular lehr

The Surface modular lehr offers a final solution to the company which wants to replace obsolete equipment, but dreads the excessive engineering costs of new units.

This lehr is really a series of standardized modules, which can be linked together to reproduce any prescribed temperature curve. This type of design saves you money because it spreads the engineering costs over many modules, and makes assembly fast and economical.

This lehr has many other features. In many cases, it makes replacement more profitable than retaining outmoded equipment. Please let us tell you more about it.



The new Surface modular lehr, annealing television tubes.

Surface Combustion • 2378 Dorr St., Toledo 1, O.
A Division of Midland-Ross Corporation • *In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ontario*

wherever heat is used in industry

Surface

NEWS
IN THE GLASS INDUSTRY

Personalities...

Maurice L. Stonehill

Chairman and chief executive officer, Jeannette Glass Company; succeeds Kirk W. Todd, retiring.

Elected to board of directors: John B. Fowler, Jr., Victor D. Ziminsky, and Harold H. Kahn.

Maurice L. Stonehill

Paul A. Ketchum

Todd's son, Burt K. Todd, continues as president and member of the board. Rolland L. Ehrman and Francis S. McMichael also remain on the board.

Company manufactures pressed and blown tableware, kitchenware, giftware and other glass products.

Paul A. Ketchum

Vice president in charge of glass sales for Pittsburgh Plate Glass Company's merchandising division.

Frank T. Cantrill

Manager, glass container division (Detroit), Owens-Illinois Glass Company.

With the company since 1946, he has also headed division branches in Oklahoma City, Richmond, Va., and New York.

J. J. Spurrier

Sales manager for the glass industry, A. P. Green Fire Brick Company.

Donald G. Sturges

Director of research and development for Carborundum Company. Succeeds Major General Leslie E. Simon, U. S. Army Ret.

Col. Paul N. Gillon, U. S. Army Ret., is director of research and development for Carborundum International S. A., Geneva, Switzerland.

Dr. Howard E. Kremers

District manager, market development for American Potash & Chemical Corporation. Responsible for corporate market development activities assigned to the eastern district.

Dr. Howard E. Kremers

James F. Riley

James F. Riley

Field sales manager for Corning Electronic Components, a department of Corning Glass Works. George B. Jensen succeeds Riley as department sales engineer for the West Coast.

Mr. Riley will direct nation-wide field sales of metallized glass components, resistors, capacitors, and Fotoceram circuit boards.

Ralph L. Sanford

Manager, Walsh Refractories Corporation St. Louis plant. Assisted by Eugene D. Barron in the production of slip cast refractories and high temperature specialties and by Dale L. Rockwell in the production of fusion cast refractories.

Maurice E. LeRoy

Secretary-treasurer, Harbison-Carborundum Corporation; Karl H. Sandmeyer, technical director; Arthur L. Donnenwirth, manager of manufacturing; and Roy W. Brown, sales manager. The firm was recently organized on an equal ownership basis by Harbison-Walker Refractories Company, Pittsburgh, Pa., and The Carborundum Company, Niagara Falls, N. Y.

Mr. LeRoy was formerly assistant division controller and Mr. Sandmeyer, supervising engineer of fused cast refractories at Carborundum. Mr. Donnenwirth was manager of Carborundum's refractories plant at Falconer, N. Y., and Mr. Brown, product sales manager of Carborundum's refractories division at Perth Amboy, N. J.

J. W. Copeland

R. R. Nickerson

Peter Kirkman

Albert N. Guthrie

John W. Copeland

Succeeds R. R. Nickerson as plant manager, Libbey-Owens-Ford Glass Company plant, Ottawa, Ill. Mr. Nickerson is now special assistant to the executive vice president of production.

Peter Kirkman, Albert N. Guthrie and Reuel P. Lynott are first assistant plant manager, assistant plant manager and production manager, respectively. John D. Hemley is special administrative assistant to the plant management; William Kirkman, laminating plant superintendent; and Lester N. Kramer, industrial relations manager.

J. A. Pierce

Manager, technical sales, Harbison-Walker Refractories Company. Has served in the technical sales department since 1951.

Adolph F. Langerman

Awarded 45-year pin by O. Hommel Company. He is supervisor of frit quality control and second oldest employee in length of service.

Ernest M. Hommel, president, conducted ceremonies presenting 30-year pins to Joseph J. Kostishack and Herman Vock; 25-year pins to John H. Clatty, Anthony W. Pappas, Herbert P. Jones, Gerald Aspell and Joseph J. Swartzmiller. Mr. Hommel received a 35-year pin in 1958.

Adolph F. Langerman receiving O. Hommel Company's 45 year pin from Ernest M. Hommel, president of the company.

Paul Luscher

Technical assistant to general manager, Fiber Glass division, Pittsburgh Plate Glass Company.

He will be in the technical, orientation and liaison program at the Shelby, N. C., Fiber Glass plant.

Fred P. Boehm

Assistant director of sales, with Charles E. Varn, for Solvay Process Division, Allied Chemical Corporation.

Robert E. Clagett is sales manager, Pittsburgh branch; G. Richard Barclay, sales manager, New Orleans branch; Jerome L. Hochenedel, manager, Houston sales; and Richard A. Marshall, manager, organic chemicals section.

Joseph A. Celaschi, James H. Bierer

General sales manager and marketing manager, respectively, for the consumer products division of Corning Glass Works.

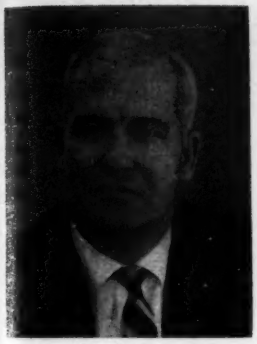
Celaschi will coordinate and direct all sales activities of the division; Bierer will coordinate product development, market research, planning, promotion and advertising.

John D. Sullivan

Recipient of 1960 Albert Victor Bleininger Award, highest honor conferred in this country for distinguished achievement in the field of ceramics. Medal and scroll representing the award will be presented at The Bleininger Award Dinner, March 11, at The Pittsburgh Athletic Association.

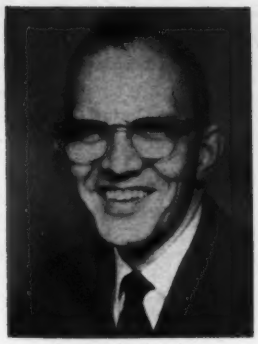
Joined Battelle Memorial Institute in 1931; now technical director. Previously employed by U. S. Bureau of Mines in positions of analyst at the Northwest Experiment Station, assistant physical chemist at the Pacific Experiment Station and associate metallurgical chemist at the Southwest Experiment Station.

Fellow and Honorary Member of The American Ceramic Society and served as treasurer, vice president and president for the organization. Member of The British Ceramic Society, Deutsche Keramische Gesellschaft (German Ceramic Society), American Society for Testing Materials, National Academy of Sciences and Fellow of the Society of Glass Technology.



Revel Lynott

Thomas M. Gillan



Everett G. Couch, Jr.

Raymond B. Lippincott, Jr.

Thomas M. Gillan

Vice president, Corning Glass Works of Canada Limited. He will direct the sale and distribution of Pyrex and Corning Ware Cooking and Kitchen utensils to the Canadian market. The firm operates a manufacturing plant and distribution center at Leaside, Ontario

Everett G. Couch

Production manager for Chas. Taylor Sons Company; formerly with Anchor Hocking Glass Corporation and Corhart Refractories Company. Transferred from Taylor, Ky., to Cincinnati, O.

Raymond B. Lippincott, Jr., succeeds Couch at the Taylor works; formerly with Sayre and Fisher Brick Company.

Companies...

Henry F. Teichmann, Inc.

Expands engineering department and company offices in Washington County, Pa., by 1800 sq. ft. Firm is currently supervising construction or operation of glass manufacturing facilities in three foreign countries.

National Bureau of Standards

Using new prefixes for denoting multiples and submultiples of units, following the recommendations of the International Committee on Weights and Measures.

In addition to the 8 numerical prefixes in common use the Committee, in its fall Paris meeting (1958), expanded the list by adding 4 prefixes (symbols are in parentheses): 10^{-12}, pico (p); 10^{-9}, nano (n) 10^{9}, giga (G); 10^{12}, tera (T). The 8 prefixes in use at present are: 10^{-6}, micro ($m\mu$); 10^{-3}, milli (m); 10^{-2}, centi (c); 10^{-1}, deci (d); 10, deka (dk); 10^{2}, hecto (h); 10^{3}, kilo (k); and 10^{6}, mega (M).

Pennsylvania Glass Sand Scholarships

Merit Award Scholarships presented to eleven ceramic engineering students for the current year.

Recipients are: George H. Daggett, Jr., Alfred University; Allan P. Sloan, Jr., Clemson Agricultural College; Michael F. Berard, Iowa State College; Paul R. Gage, Ohio State University; Charles L. Booth, Pennsylvania State University; Richard Kleiner, Rutgers-The State University; Robert H. Baker, University of Illinois; Norman J. Frossard, Jr., University of Missouri; Gary Hillman, Georgia Institute of Technology; Richard W. Allen, University of Texas and Alan V. King, University of Washington. Scholarships provide full tuition for senior year in ceramic engineering.

Findlay Clay Products Company

Changed their name to Findlay Refractories Company to better identify their products. Company was founded in Findlay, O., in 1888 to manufacture glass melting pots.

Additional manufacturing facilities were built at Washington, Pa., during the turn of the century. The Ohio plant was closed in 1927 and manufacturing was concentrated at the Pennsylvania plant.

Today 80 per cent of production consists of tank blocks and special refractory shapes for the glass industry. The company is the developer and patentee of the Vacuum Casting Process for manufacturing clay tank blocks.

Engelhard Industries, Inc.

Established Industrial Diamond Division to import, stock, process and sell industrial diamonds in U.S. Provides technical service, application engineering and basic research to industrial users of diamonds.

Current research projects confirm selected shapes and specially treated natural diamonds are proving superior in certain applications to unselected and untreated material. Wider use of industrial diamonds for the glass industry is being investigated.

Bikita Minerals (Private) Ltd.

Purchased large high-grade petalite property adjoining its lepidolite deposit in Southern Rhodesia, Africa. As single mining operation, two properties

will furnish all types of lithium ores to glass industry.

Newly acquired property contains large reserves of high-grade petalite and subsidiary spodumene and eucryptite; the other property contains lepidolite and beryl, with subsidiary spodumene, amblygonite, and pollucite.

Major shareholders of Bikita: American Metal Climax, Inc., American Potash & Chemical Corporation, and Selection Trust, also technical manager. American Potash produces lithium carbonate, lithium hydroxide, lithium metal and wide variety of lithium chemicals.

Corning Glass Works

Introduced new standard and regenerative shell and tube heat exchangers, designed for processing corrosive fluids, with a 60-square-foot capacity.

The regenerative service units are jacketed in hard, low expansion borosilicate glass which is highly resistant to heat, shock and corrosion. A steel jacket is used on the standard units which are engineered for cooling operations.

Bundles of 31 Pyrex brand glass tubes, three fourths of an inch in diameter, are tightly packed in the 60-foot exchangers. The tight tube packing is said to increase outside film coefficient by over 12 per cent. Working pressure can be as high as 20 psi. Operating temperatures up to 200°F can be maintained on the shell side and up to 375°F can be maintained on the tube side. Overall values of U have been measured up to 213 BTU/hr/ft^2/degree F in water-to-water tests.

The units are 10 feet, six inches long and the shell diameter of the 60-foot models is six inches. The company is also producing a 13½ foot capacity model with a shell diameter of three inches.

The glass jacketed model of the larger unit has a dry weight of 252 pounds and the steel jacketed model weighs 297 pounds. In the smaller unit the dry weight of the glass jacketed model is 67 pounds and the steel shell model weighs 91 pounds.

Corning Glass Works' tube and shell heat exchangers with self-aligning header assemblies. Capacity is 60-sq. ft. Glass jacketed models are designed for regenerative service and steel jacketed models are for cooling operations.

Fischer & Porter Co.

Leased two-story plant of Davisville Hosiery Mill, Inc., Warminster Township, Pa., to expand production facilities of industrial glassware and laboratory apparatus, digital data acquisition and water and waste treatment, and process control.

Building contains 20,000 sq. ft. of space with office facilities and manufacturing operations space.

Knox Glass Inc.

Declared 25¢ per share dividend, payable March 10 to shareholders of record on February 25.

Alexander W. Lansberg elected vice president and assistant to the president. Re-elected officers: Dr. Arthur W. Wishart, president; Clarence R. Deible, and C. L. Rossman, vice presidents; J. D. Lynch, secretary; E. C. Mayfield, assistant secretary and assistant treasurer.

Pemco Co.

Commemorated 50th Anniversary at company's annual dinner. James Pierson and Philip Lubertine received Heinrich and Karl Turk Merit Award for outstanding contribution to the company. Pierson developed a new series of decorative matt glass enamels and Lubertine developed specifications for a basic raw material used by the firm.

Philip Lubertine and James Pierson receiving Pemco's Heinrich and Karl Turk Merit Award for outstanding contribution to the company from Richard Turk.

George H. Spencer-Strong, vice president and chairman of the awards committee presented service awards to employees with the company for periods up to forty years.

Owens-Illinois Glass Co.

Purchased minority interest in Actien-Gesellschaft der Gerresheimer Glashuttenwerke, vorm. Ferd. Heye, Dusseldorf, Germany and concluded agreement with German company for exchange of technical assistance and patent licenses.

Owens-Illinois obtained 25 per cent interest in Gerresheimer Glass in exchange for their own stock and cash. German company and seven subsidiaries produce glass containers and related products.

Johns-Manville Fiber Glass

Expansion program specifications issued for contracting bids (Defiance, O.). Program will double size of Carpenter Road plant; add 5,229 sq. ft. to Columbus Avenue factory; provide housing for special machinery for coating fiberglass insulation products; space for storage, handling and quality

Dotted lines indicate 126,000 sq. ft. expansion at Johns-Manville Fiber Glass Division's Carpenter Road plant, Defiance, O.

control of raw, processing, packaging materials, in-process materials and finished goods.

Carpenter Road expansion is second such program initiated, brings total floor space to 126,000 sq. ft. Plant serves industrial, commercial applications markets; produces fiberglass insulation for commercial heating and air conditioning units and ducts, large piping, appliances, mobile homes, refrigerated truck-trailers and railroad cars and underhood insulation for automobiles. Home insulation, marine board and other materials for residential, commercial and industrial fields are manufactured in plant at Third and Perry streets. Defiance plants employ 550, program will increase this number to over 600.

Johns-Manville's Fiber Glass Division was formed at the end of 1958 with the merger of Libbey-Owens-Ford Glass Fibers. L.O.F. merged previously with Glass Fibers, Inc., in 1955; constructed the Carpenter Road plant, purchased the Columbus Avenue building in 1957 and began manufacturing of the then newly-developed glass pipe insulation. Johns-Manville has fiberglass plants in Waterville, O.; Parkersburg, W. Va., and Corona, Calif. Waterville plant contains the research and technical center. The first six months of 1959 indicated outstanding performance for J-M's fiberglass business.

Selas Corporation

Licensed Societe Exploitation de Produits Industriels, (Paris) to manufacture and sell Selas heat processing equipment to glass, ceramics, metals, allied industries in France. Paul J. Jaye appointed application engineer, export division.

Shaw Instrument Corp.

Acquired Ceramic-Metal Assemblies Corporation by merger. Combined companies will operate as Shaw Instrument Corporation in Latrobe, Pa., manufacturer of automatic two-color pyrometer for high-temperature measurement and control, specialty electronic, and nuclear instruments.

Hazel-Atlas Glass Division

Constructing $1.5 million research and development laboratory at Plainfield, Ill., for research on glass compositions, melting, new methods of forming and treating glass, and developing new glass container products.

Equipment development group will design devices

Architect's drawing of Hazel-Atlas Glass Company's $1.5-million research and development laboratory, Plainfield, Ill.

to form, inspect, handle glass containers. Front single-story portion will contain administrative offices, library and cafeteria; Rear two-story portion, laboratories, shops and pilot area.

Christy Works

Shipped a 6,000 pound (unburned) glass melting tank "floater" to Pittsburgh Plate Glass Company's window glass furnace plant (Mt. Zion, Ill.). Measures 16" x 24" x 196" over-all, constructed of clay mix specially prepared in a vacuum and slip cast into large mold.

Christy glass house clay manufacturing plant has been highly successful in manufacturing large and difficult shapes for the glass industry.

Obituaries...

Mrs. Mary Ellen Frazier

Mrs. Mary Ellen Frazier, wife of Chauncey E. Frazier, chairman of the board and former president of Frazier Simplex, Inc., died December 13, 1959, in Washington, Pa.

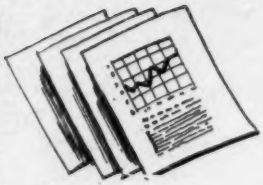
Ralph Warner Harbison

Ralph Warner Harbison, former president of Harbison-Walker Refractories Company, died December 12, 1959, in Pittsburgh, Pa. He was widely known for his civic, educational and philanthropic interests and was the founder of the YMCA National Council.

William L. Slater

William L. Slater, district industrial sales manager for Libbey-Owens-Ford Glass Company in Chicago, died December 26, 1959, in Atlanta, Ga.

He joined the company in 1939 and during his 20 years of service had held sales positions in Atlanta, Nashville and Memphis. He became an industrial sales representative in 1942 and was promoted to district industrial sales manager in Chicago in 1947.



RESEARCH DIGEST

Effect of Fluorides on Infrared Transmittance of Certain Silicate Glasses

● FLUORIDES HAVE LONG BEEN USED in the manufacture of certain glasses, particularly milk glasses and opal glasses. Normally, the amount of fluoride needed to produce opalescence in silicate glasses is small (about 4 weight per cent). Fluorides also are used in industrial glass production as "refining agents" and as "mineralizing" or "fluxing agents." As such they act to decrease the viscosity of the glass melt, aiding in the removal of gasses from the melt and in lowering the temperature at which the batch materials become fluid.

It has been established by many investigators that silicate glasses have a small amount of water in their internal structure, and this water content causes a strong absorption band in the region of 2.7 to 3.0 μ. In an infrared-transmitting glass, it is desirable to eliminate this absorption band, if possible. As pointed out by Scholze and Dietzel, other workers have found that the intensity of the "water band" can be decreased by various techniques, including vacuum melting, bubbling of a dry gas through the melt, use of anhydrous batch materials, and careful control of the furnace atmosphere. These methods, however, are difficult to use outside the laboratory and may be impractical in the large-scale manufacture of glass.

The present paper by Cleek and Scuderi (*Journal American Ceramic Society*, December 1959) describes a method of eliminating much of the water-band absorption in certain types of silicate glasses by including fluorides as constituents of the glasses, and although it has been used only on laboratory-scale melts, it appears to be applicable to melts of any size.

From the results it would appear that the solubility of fluorides in silicate melts in increased when La_2O_3 or Ta_2O_5 is present. Haszeldine and Sharpe point out that "the fluorides of the less electropositive metals and nonmetals combine with the alkali- and alkaline-earth fluorides to yield complex salts." Some of the ions found are $(ZrF_7)^{3-}$ and $(TaF_7)^{2-}$. Whether or not ions of this type exist in the glass melts is not known. The fact remains, however, that the use of La_2O_3 and Ta_2O_5 permits a greater amount of fluorides to be incorporated into the batch, and the resulting melt to be cooled as a transparent glass, than if these oxides were not present. Tha some of the fluorides remained is evidenced by the ob servation that in general the refractive index decrease as the fluoride content of the batch increased. The some what erratic results in the transmittance data, and in th refractive index values may be due in part to variations from melt to melt, in the melting and fining temperature used and in the length of stirring time.

There was an increasing tendency for striae to form as the fluoride content of the batches increased. In every melt that contained 4 mole per cent or more of fluoride, striation was observed. In the melts with the higher AlF_3 content, striae were so bad that it appeared almost as though a phase separation had occurred as the melts cooled. Haszeldine and Sharpe speak of the structure of fluoroaluminates and say that "these do not contain finite complex ions, but (AlF_6) octahedra joined together in infinite chains in a manner reminiscent of the silicates: the resultant compositions of the anion chains are AlF_5 and AlF_4 respectively." Perhaps the separation of fluoroaluminates was the cause of the heavy striae.

The decrease in the water-band absorption observed when fluorides are used as a batch ingredient may be explained in a number of ways. One is that the volatilization of some compound of fluorine serves to sweep out water as the bubbling of a dry gas through the melt would do. Another possibility is that the fluoride reacts with a hydroxyl group forming a bifluoride and oxide, thus reducing the hydroxyl content of the melt.

It was shown that:

(1) Relatively large amounts of fluorides can be used as components in certain silicate glass batches without causing opalescence or turbidity in the resulting glasses if certain oxides, such as La_2O_3 or Ta_2O_5, are also included in the batch.

(2) Use of fluoride decreases the amount of absorption in the region from 2.75 to 4.25 μ, thus improving the glasses for use as infrared material. The disadvantage in the use of fluorides in glasses of this type is that striation is produced, particularly when the fluoride content of the batch is more than about 4 mole per cent.

Porter Zircon Pavers for Glass Tank Bottoms

Torture test proves Porter Zircon Paver

This unretouched photograph shows comparison of Porter PZ Zircon and another commercially made Zircon Paver, after an extensive glass corrosion test. The sketch and photograph illustrate a 6″ diameter crucible with two semi-circular test pieces 1″ thick, cut and cemented with Zircon Cement to form a paved bottom. Crucible was held at 2680°F for 24 hours, filled with molten soda-lime container glass. Crucible was then cut in half across center of both test pieces to show comparison. Crucible partly immersed in liquid of same refractive index as glass to eliminate effects of saw marks and fracturing of glass and to give clear view of glass directly above and in contact with test pieces.

A Zirconium Silicate refractory made from over 99% highest grade zircon. Outstanding characteristics are P.C.E. over 42, high density, low permeability, good volume stability, high resistance to thermal spalling, excellent workmanship and high strength. Extensive glass corrosion tests indicate superiority of PZ ZIRCON to corrosion, penetration and wear. For best results lay in PZ Mortar. Complete physical and chemical properties and price available upon request to *Refractories Division, H. K. Porter Company, Inc., Porter Building, Pittsburgh 19, Pennsylvania.*

REFRACTORIES DIVISION **PORTER** **H.K. PORTER COMPANY, INC.**

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION, PEERLESS ELECTRIC DIVISION; Specialty Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION, H. K. PORTER COMPANY de MEXICO, S.A.; and in Canada, Refractories, "Disston" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

INVENTIONS AND INVENTORS

Annealing and Tempering

Bending Glass. Patent No. 2,901,866. Filed June 15, 1956. Issued September 1, 1959. No sheets of drawings; none reproduced. Assigned to Pittsburgh Plate Glass Company by Harold E. McKelvey.

This application relates to improvement in bending glass, and specifically refers to improvements in a method of bending glass sheets involving applying a compressive force to the glass edge extremities and changing the direction of application of the force as the glass is bent to pinch the glass extremities against the upper mold shaping surface and present "fall-ins" and unwanted curling of the glass tips.

The present invention provides novel improvement by incorporating insectionalized skeleton glass sheet bending mold glass edge contacting-members which are pivoted relative to the end sections to provide a compressive force to opposite glass edge surfaces at opposite extremities of the glass sheet which is to be bent while the mold is in open position. As the mold moves to its closed position, the force applied to the opposite glass edge surfaces is changed in direction so that an increasingly larger proportion is applied in a thickness direction to the upper corner of the edge surface initially contacted. This causes the extremities of the glass to be pinched against the upper shaping surface of the mold at the mold extremities, thereby preventing sliding that results in fall-ins.

Pinching the extremities of the glass sheet against the mold extremities during the final stages of the bending cycle also inhibits the tops of the glass sheets from curling off the mold tips and minimizes marking.

Tip curling has been prevented by specially constructed glass edge supporting elements which are attached securely to a hinge rod mounted on bearing supports fixed to each end section. Counterweighted lever arms are fixed to the hinge rod extremities and oriented in such a manner to provide a minimum rotational moment to rotate the glass edge contacting member relative to the end section during the initial phase of the bending cycle and to increase the moment of force causing pinching of the glass sheet extremity on the upper shaping surface of each end section outboard extremity as the bending progresses.

There were 3 claims and 12 references cited in this patent.

Glass and Wool Fiber

Amine-formaldehyde resin compositions modified with vinyl pyrrolidone polymers and preocess of sizing glass surface therewith. Patent No. 2,813,844. Filed November 18, 1955. Issued November 19, 1957. No drawings. Assigned to General Aniline & Film Corporation by Jesser Werner, et al.

The present invention relates to thermosetting compositions comprising a mixture of an amine-formaldehyde resin and a N-vinyl pyrrolidone polymer having improved adhesion to glass and fibrous glass material.

Amine-formaldehyde resins such as melamine-formaldehyde and urea-formaldehyde are successfully modified to yield excellent adhesion to glass, glass fibers, strands, mats, cloth, and other glass materials by employing a mixture containing from 80 to 97 per cent by weight of an amine-formaldehyde resin and from 20 to 3 per cent by weight of a polymer of N-vinyl pyrrolidone. By the latter term is included homopolymers of vinyl pyrrolidone and copolymers with other polymerizable vinyl monomers.

Such a resin mixture may be used not only as a laminating agent between two sheets or mats of glass, but may be used by itself as an unsupported film with glass included in its composition as a reinforcing agent. Its use as a laminating agent yields excellent structural compositions, which also have the advantage of an inexpensive amine-formaldehyde resin. Despite the fact that the modified amine-formaldehyde composition may contain as much as 20 per cent of a N-vinyl pyrrolidone either in the form of a polymer or copolymer, the resulting laminates and films, even after prolonged water immersion, display tenacious adhesion to glass, and with no apparent leaching.

There were 12 claims and the following references cited in this patent.

United States Patents

2,244,184, Austin et al., June 3, 1941 and 2,667,473, Morner et al., Jan. 26, 1954.

Sheet and Plate Glass

Grinding and polishing table unlocking device. Patent No. 2,886,925. Filed December 2, 1957. Issued May 19, 1959. No sheets of drawings; none reproduced. Assigned to Pittsburgh Plate Glass Company by Vance A. Firestone.

This invention broadly relates to grinding and polishing plate glass, and more particularly to apparatus for automatically unlocking adjacent tables which support sheets of plate glass for grinding and polishing operations.

The portion of the locking mechanism received in the trailing end of a table includes a latching jaw element resiliently mounted for limited longitudinal movement and having an upstanding engaging flange or jaw extending beyond the end of the table for cooperation with the portion received within the leading edge of the adjacent

table. The latching element is provided with a jaw insert attached to the engaging flange, the outer extremity of which is provided with a curved surface thereon. The element is attached or made integral with a longitudinally disposed threaded rod supported for sliding motion by means of spaced, cylindrical bushings and the bushings are retained within a housing fixed within the table and provide a cavity to receive resilient means in the form of a pair of relatively strong compression springs.

The portion of the locking mechanism received within the leading end of the table includes a latching jaw element having a depending engaging flange or jaw to which is fixed a jaw insert.

The curved surfaces of the jaw allow smoother engagement and disengagement of the latching elements.

There were five claims and the following references cited in this patent.

United States Patents

1,679,472, Hitchcock, Aug. 7, 1928; 1,861,659, Fox, June 7, 1932; 1,901,511, Handy, Mar. 4, 1933; 1,913,-994, Price, June 13, 1933.

Tube and Cane Machines

Glass tube joint. Patent No. 2,877,714. Filed July 9, 1956. Issued October 28, 1958. No sheets of drawings; none reproduced. Assigned to Staatsbedrijf der Posterijen, Telegrafie en Telefonie by Bastiaan Everardus Bol Raap.

This invention relates to a glass joint between two glass tubes differing in melting point and coefficient of expansion.

Generally speaking, the joint of this invention comprises one or more relatively narrow transition glass rings between two glass tubes of different coefficients of expansion, and/or different melting points which rings have a wall thickness considerably less than that of the wall of either of the two glass tubes.

Such thin glass transition rings are formed by first closing the ends of the two tubes to be joined together so that their closed ends have thin walls, next blowing in the center of each of these thin end walls small holes, attaching a small droplet of transition glass to the glass tube of lower coefficient of expansion or higher melting point. The next step is to blow a similar small hole in this droplet, repeating the last two steps for each further transition glass to be used, connecting the small holes in the last transition glass and in the glass of higher coefficient of expansion or lower melting point, and lastly blowing the connected small holes through the ends and droplets out into the desired outside diameter for the tube joint.

The annular transition rings thus formed are narrow and of thicknesses considerably less than the thickness of the walls of either of the tubes because of the relative small size of the droplets employed. These thin walled fused transition glass rings or sections have considerably decreased internal tensions and stresses than those of

(*Continued on page* 115)

THE GLASS INDUSTRY

For 1959

BOUND VOLUMES for the year 1959 (with index) now available

$11.00 ea. domestic and foreign

BOUND VOLUMES for the year 1958 (with index) are still available but supply is limited

$11.00 ea. domestic and foreign

THE GLASS INDUSTRY
55 W. 42 St., N.Y. 36, N.Y.

Please send me:

☐ One copy of THE GLASS INDUSTRY 1959 BOUND Volume.

☐ One copy of THE GLASS INDUSTRY 1958 BOUND Volume.

Name _____

Company _____

Address _____

☐ Bill me ☐ Check enclosed*

* Postage and handling: add 75c domestic; $1.25 foreign.

NEW BOOKS

SYMPOSIUM ON MICROSCOPY, STP 257. 170 pages, $4.75

The American Society for Testing Materials, Committee E-1 on Methods of Testing, sponsored this symposium with the intention of covering most of the recent developments in light- and electron-microscopy and the effective application of this science to laboratory research and industrial production. The purpose of the symposium was also to disseminate knowledge of progress and emphasize the need for continuous refinements and improvements in microscopical techniques.

The field of microscopy is reviewed, and its future possibilities outlined.

Contents

Introduction. F. F. Morehead, research and development division, American Viscose Corp., Marcus Hook, Pa.

Measurement with Phase and Interference Microscopes. Oscar W. Richards, chief biologist, research department American Optical Co., Southbridge, Mass.

Performance Characteristics of Objectives, Eyepieces, and Illuminators for Microscopy. H. W. Zieler, Zieler Instrument Co., Boston, Mass.

Chemical Microscopy in the Optical Industry. Germain Crossmon, Bausch & Lomb Optical Co., Rochester, N.Y.

The Study of Opaque Minerals in Reflected Light. Eugene N. Cameron, professor of geology, Department of Geology, University of Wisconsin, Madison, Wisc.

Application of Electron Microscopy in the Petroleum Industry. H. M. Allred, research and technical department, Texaco Research Center, Beacon, N.H.

The Electron Microscope in the Study of Minerals and Ceramics. Joseph J. Comer, associate professor of mineral sciences, College of Mineral Industries, Pennsylvania State University, University Park, Pa.

The Structure of Synthetic Fibers. Robert G. Scott, textile fibers department, experimental station, Pioneering Research Division, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

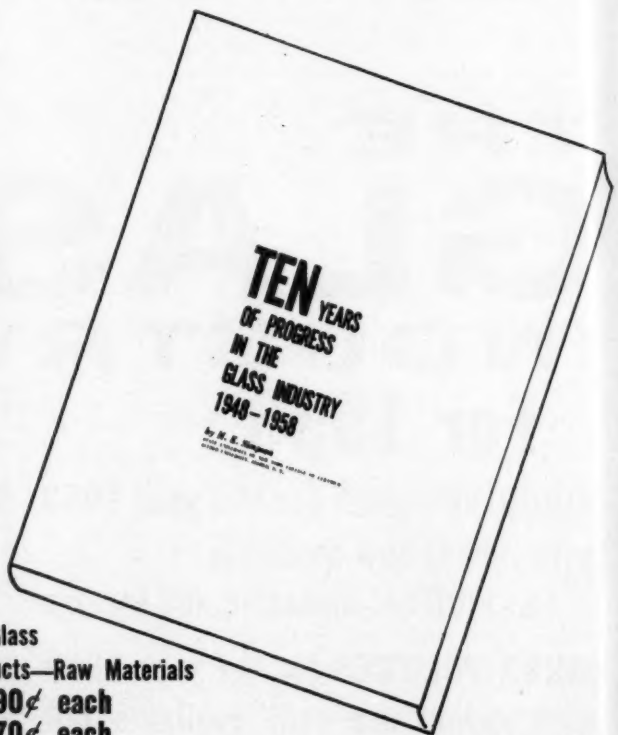
Microscopical Studies of Failure in Polymers. Sanford B. Newman, National Bureau of Standards, Washington, D. C.

(*Continued on page* 115)

TEN YEARS OF PROGRESS IN THE GLASS INDUSTRY

40 Pages

by H. E. SIMPSON, ALFRED UNIVERSITY



This comprehensive report was originally published in THE GLASS INDUSTRY in two installments (November and December, 1959).
Traces 10-year progress (1948-1958) in:

Glass Containers—Fiber Glass—Flat and Structural Glass
Electronics Industry—Technical Advances—New Products—Raw Materials

1-10 copies $1.00 each 11-50 copies **90¢ each**
51-99 copies .80 each 100 or more copies **70¢ each**

AVAILABLE FROM—

THE GLASS INDUSTRY 55 West 42nd Street, New York 36, New York

Soon To Be Published

Vol. II. HANDBOOK OF GLASS MANUFACTURE

Volume I of the Handbook of Glass Manufacture was originally published in 1953 by the Ogden Publishing Company. Uninterrupted demand for the book necessitated a second printing in 1957 in order to meet the needs of all those concerned with glass manufacture, technology and engineering. Both the first and second printing of Volume I have been sold out.

As a supplement to the first edition, Volume II of the Handbook of Glass Manufacture will be published on or about March 1, 1960, and will again be edited by Dr. Fay V. Tooley, Professor of Glass Technology, Department of Ceramic Engineering, University of Illinois.

CONTENTS . . .

Chemical and Instrumental Analysis of Glass
Francis Glaze, Consultant
John Time, Owens-Corning Fiberglas Corp.

Optical Properties of Glass: Effects of Radiation on Glass
Norbert J. Kreidl, Bausch and Lomb Optical Co.

Scientific Glass Blowing
Vincent DeMaria, Glass Products Development Laboratory

Flat Glass Manufacturing Processes
Roy G. Ehman, Pennsylvania State University

The Quality Control Chart
Ronald Wiley, Owens-Corning Fiberglas Corp.

Electric Melting of Glass
Larry Penberthy, Penberthy Instrument Co.

Constitution and Structure of Glass
Fay V. Tooley, University of Illinois

The Glass Industry
55 West 42nd Street, New York 36, New York

Date.....

Enclosed please find remittance in the amount of $..... to cover the cost of ..... copy(ies) of Volume II of the HANDBOOK OF GLASS MANUFACTURE. Single copy price, $10.00. Order for 5 or more copies, 10% discount. Add Shipping and Insurance charges, domestic 60¢ per copy; foreign 90¢ per copy. Foreign remittance in U.S. dollars.

NAME.....

COMPANY.....

STREET..... CITY..... STATE.....

NEW EQUIPMENT AND SUPPLIES

Batch Mixer

Daffin Mfg. Co., Lancaster, Pa., is producing a line of batch mixers for precision-blending of dry, free-flowing materials. Machine uses a series of interior channel separators with low-speed rotation that divides pyramids and blends ingredients twice each revolution. Model capacities range from several pounds to 16 tons.

Handbook

Precision Equipment Co., Chicago, Ill., is offering a free one-year's subscription for their equipment manual. Publication describes and illustrates products and inventions for both plant and office.

Temperature Control Valve

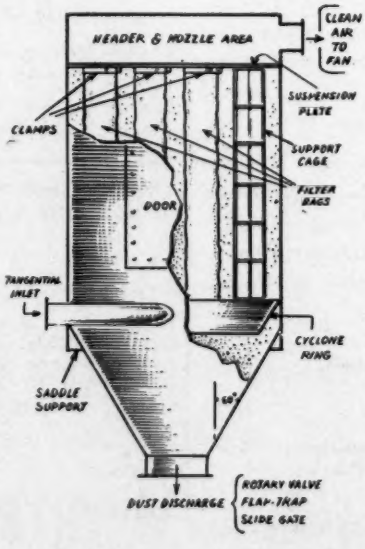
OPW-Jordan Corp., Cincinnati, O., has available piloted temperature control valves in ¼" to 2" sizes for sensitive control of rugged pressure drops. The valves are used to control temperatures of instantaneous heaters, oil preheaters, storage heaters and process heating and cooling applications. Sliding gate, self-lapping, self-cleaning seats are used to insure positive tight, shut-off during lock up and accurate regulation during operation. Devices are suitable for pressures up to 250 psi and temperatures up to 500°F.

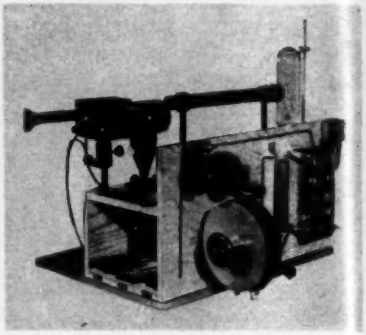
Hopper Weight Control

W. C. Dillon & Co., Inc., Van Nuys, Calif., has developed a switch that automatically releases a pre-set weight from the hopper and sets it up for reloading. The device accommodates 20,000 pounds as a standard load. The switch is comprised of a U-shaped deflection beam that is loaded by means of eyes attached to opposite sides and as the beam deflects outwardly, it trips related switches at precise load points. The unit is enclosed in a metal housing that seals out dirt, dust, water and weather.

Dust Collector

Flex-Kleen Corp., Chicago, Ill., has introduced a self-cleaning dust collector with no moving parts. The apparatus receives dust-laden air through a tangential cyclone ring, and the heavier materials are dropped while the lighter materials are collected on the outside of the filter tubes. Tubes are intermittently flexed taut by bursts of compressed air in a continuous series of sequences for cleaning. There are six standard sizes with 2,000 to 12,000 CFM. It can be suspended from the ceiling or floor mounted.





Pyrometer Calibrator

Pyrometer Instrument Co., Inc., is offering an optical pyrometer calibrating set which is said to permit accurate and simultaneous calibration of any two optical pyrometers irrespective of manufacture.

Instrument has certificate of calibration obtained from equipment calibrated at the National Bureau of Standards. Wide filament strip type lamp can be adjusted by step and vernier rheostats to any desired temperature in the range from 1400°F to 4200°F (800°C to 2300°C).

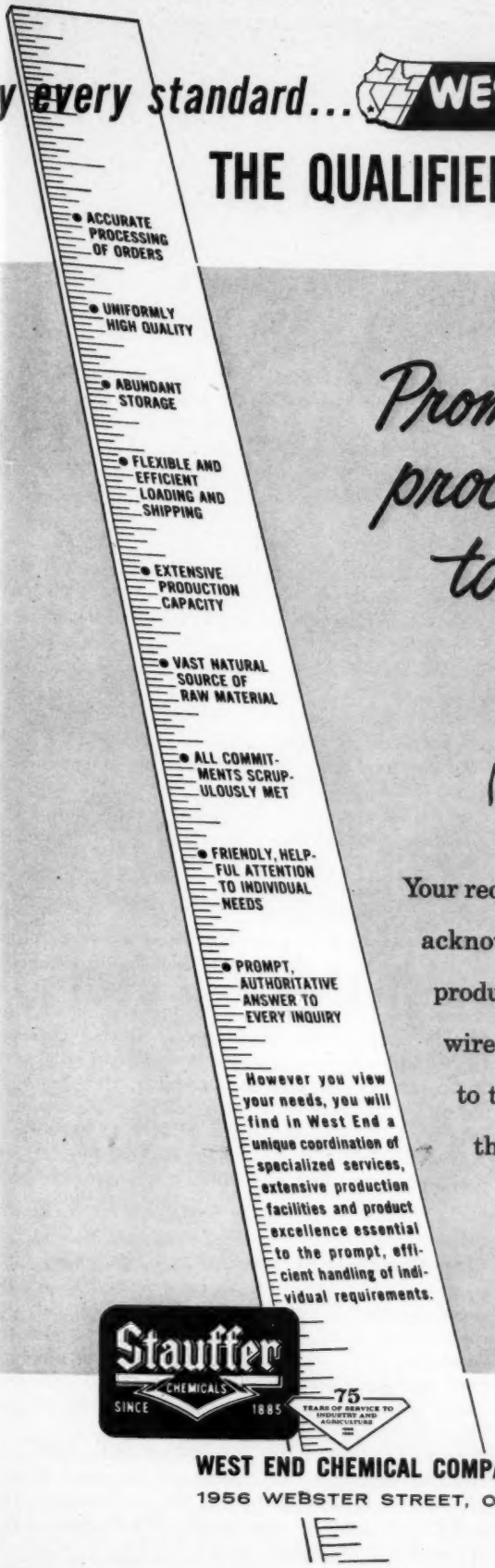
CATALOGS RECEIVED

Recorder. (3 pages) Description of SR recorder and strip recorder with 250 mm chart width and one second balancing speed. Illustrated with specifications.
E. H. SARGENT & CO., Chicago, Ill.

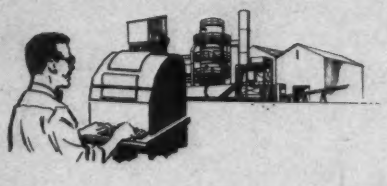
Counting devices. (8 pages) Describes revolution counters, geared counters, ratchet counters, and counters featuring high speed, reset, lineal measuring, remote data readout, predetermining of quantities or other quantitative data. Illustrated.
VEEDER-ROOT INC., Hartford, Conn.

Physical science products. (112 pages) Catalog describes over 300 products including optical benches, cathetometers, galvonometers and electron impact tubes. Catalog supplements are issued on a quarterly basis.
THE EALING CORP., Cambridge.

By every standard... WEST END MEASURES UP AS THE QUALIFIED SUPPLIER OF SODA ASH


• ACCURATE PROCESSING OF ORDERS
• UNIFORMLY HIGH QUALITY
• ABUNDANT STORAGE
• FLEXIBLE AND EFFICIENT LOADING AND SHIPPING
• EXTENSIVE PRODUCTION CAPACITY
• VAST NATURAL SOURCE OF RAW MATERIAL
• ALL COMMITMENTS SCRUPULOUSLY MET
• FRIENDLY, HELPFUL ATTENTION TO INDIVIDUAL NEEDS
• PROMPT, AUTHORITATIVE ANSWER TO EVERY INQUIRY
However you view your needs, you will find in West End a unique coordination of specialized services, extensive production facilities and product excellence essential to the prompt, efficient handling of individual requirements.

Prompt, accurate processing of orders to last detail



Your requirements as to shipping dates, routing, acknowledgements, advices, scheduling and product specifications are relayed by private wire teletype from the Oakland Sales Office to the responsible plant personnel who see that orders are filled exactly as written.

Stauffer CHEMICALS SINCE 1885 — 75 YEARS OF SERVICE TO INDUSTRY AND AGRICULTURE

WEST END CHEMICAL COMPANY • DIVISION OF STAUFFER CHEMICAL COMPANY

1956 WEBSTER STREET, OAKLAND 12, CALIF. • PLANT: WESTEND, CALIF.

CURRENT STATISTICAL POSITION OF GLASS

Employment in the glass industry during November, 1959, was as follows: *Flat Glass:* a preliminary figure of 32,000 for November, 1959, indicates a decrease of 1.8 per cent under the adjusted figure of 32,600 reported for October, 1959. *Glass and Glassware, Pressed and Blown:* an increase of 5.1 per cent is shown by the preliminary figure of 87,300 reported for November, 1959, when compared with the adjusted figure of 83,000 reported for October, 1959. *Glass Products Made of Purchased Glass:* the preliminary figure of 15,700 given for November, 1959, is 0.6 per cent over the adjusted figure of 15,600 reported for October, 1959.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	December, 1959
Food	910,000
Medicinal and Health Supplies	1,316,000
Chemical, Household and Industrial	709,000
Toiletries and Cosmetics	729,000
Beverage, Returnable	841,000
Beverage, Non-returnable	142,000
Beer, Returnable	162,000
Beer, Non-returnable	646,000
Liquor	522,000
Wine	414,000
Sub-total (Narrow)	6,391,000

Wide Mouth Containers

Food	*3,029,000
Medicinal and Health Supplies	347,000
Chemical, Household and Industrial	174,000
Toiletries and Cosmetics	158,000
Packers' Tumblers	49,000
Dairy Products	181,000
Sub-total (Wide)	*3,938,000
Total Domestic	10,329,000
Export Shipments	283,000
TOTAL SHIPMENTS	*10,612,000

*This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production December 1959	Stocks December 1959
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics	Narrow Neck	4,130,000	6,682,000
	Wide Mouth	*3,797,000	*6,220,000
Beverage, Returnable		736,000	1,721,000
Beverage, Non-returnable		161,000	245,000
Beer, Returnable		238,000	420,000
Beer, Non-returnable		684,000	852,000
Liquor		669,000	1,623,000
Wine		506,000	688,000
Packers' Tumblers		138,000	216,000
Dairy Products		198,000	286,000
TOTAL		*11,257,000	*18,953,000

*This figure includes Fruit Jars and Jelly Glasses.

Payrolls in the glass industry during November, 1959, were as follows: *Flat Glass*: a decrease of 4.7 per cent is shown in the preliminary $17,490,067.84 given for November, 1959, when compared with October's $18,363,254.00. *Glass and Glassware, Pressed and Blown*: an increase of 5.2 per cent is shown in the preliminary $33,386,189.63 reported for November, 1959, when compared with the previous month's adjusted $31,712,967.02. *Glass Products Made of Purchased Glass*: a preliminary figure of $5,113,672.28 was reported for November, 1959. This is an increase of 1.4 per cent when compared with the adjusted figure of $5,039,868.29 for October, 1959.

Glass Container Production based on figures released by the Bureau of the Census, Industry Division, was 11,257,000 gross during December, 1959. This is a decrease of 7.6 per cent under the previous month's production figure of 12,188,000 gross. During December, 1958, glass container production was 10,515,000 gross, or 6.5 per cent less than the December, 1959 figure. At the end of the year 1959, glass container manufacturers have produced a preliminary total of 153,159,000 gross. This is 5.9 per cent more than the 144,494,000 gross produced during the year 1958.

Glass Container Shipments during December, 1959, came to 10,612,000 gross, an increase of 20.8 per cent over November, 1959. Shipments during December, 1958, amounted to 10,725,000 gross, or 1.1 per cent more than December, 1959. At the end of the year 1959, shipments have reached a preliminary total of 151,709,000 gross, which is 6.2 per cent more than the 142,745,000 gross shipped during the year 1958.

Stocks on hand at the end of December, 1959, came to 18,953,000 gross. This is 3.4 per cent more than the 18,324,000 gross on hand at the end of November, 1959, and 2.2 per cent more than the 18,537,000 gross on hand at the end of December, 1958.

ON HOMMEL *GLASS COLORS*

At some point in the world, every minute of the day, a product bearing Hommel glass colors is being used. Their quality is known and respected around the world. These superior colors build sales through customer satisfaction.

And Hommel glass colors are so easy to work with . . . reduce actual production costs. Whether your production requires hot or conventional squeegee printing, spraying, or brush application, you will find Hommel Glass Enamels more than meet every requirement. Samples are available without obligation.

SPECIFY HOMMEL

GLASS COLORS

THE O. HOMMEL CO. PITTSBURGH 30, PA.

West Coast Warehouse, Laboratory 4747 E. 49th Street, Los Angeles, California Dept. GI-260

POTTERY • STEEL AND CAST IRON FRIT
CERAMIC COLORS • CHEMICALS • SUPPLIES

Our Technical Staff and Samples are available to you without obligation. Let us help with your problems.

World's Most Complete Ceramic Supplier

(*Continued from page* 73)

Sales are expected to remain fairly stable, with approximately 10 per cent of TV households re-entering the market each year.

Table and clock radio demand will continue the upward trend evidenced in the last few years, with approximately 11 per cent of households purchasing a radio each year.

TABLE III

THE HOME ENTERTAINMENT MARKET

ESTIMATED RETAIL SALES

1960-1965

(UNITS—MILLIONS)

Product Line	1960	1961	1962	1963	1964	1965
Television	5.9	5.9	5.9	6.0	6.1	6.2
Table and Clock Radios	5.5	5.7	5.8	5.9	6.0	6.0
Portable Radios (Domestic)	3.2	3.0	2.8	2.5	2.5	2.5
Auto Radios	4.9	5.1	5.1	5.1	5.1	5.1
Hi-Fi Phonographs	2.7	2.5	2.1	2.1	2.0	2.0
Standard Phonographs	2.2	2.3	2.4	2.5	2.5	2.6

Domestic portable radio sales will probably be affected by imports, particularly from Japan.

Auto radio sales are estimated at 85 per cent of the anticipated yearly car output of approximately 6 million units.

TABLE IV

THE HOME ENTERTAINMENT MARKET

ESTIMATED ENTERTAINMENT

RECEIVING TUBE DEMAND

1960-1965

Initial Equipment

Year	Units (Millions)
1960	188
1961	181
1962	170
1963	158
1964	150
1965	140

Hi-Fi phonograph sales (list price over $75) are expected to reach 2.7 million units this year.

Sales of standard phonographs will show a modest growth through 1965 paralleling the increase in household formations.

TABLE V

THE HOME ENTERTAINMENT MARKET

ESTIMATED ENTERTAINMENT

RECEIVING TUBE DEMAND

1960-1965

Renewal Market

Year	Units (Millions)
1960	187
1961	196
1962	204
1963	213
1964	215
1965	215

Entertainment receiving tube demand is based on such factors as estimated set production, number of tubes per set and projected transistor penetration rates. A sizable initial equipment market is expected during the next 10 years as transistor penetration in TV remains at a minimum.

Entertainment receiving tube demand is expected to increase from 180 (1959) to 215 million units by 1964-1965, paralleling the anticipated growth of tube sockets in use. The market will probably plateau at approximately 200-215 million units during the period 1966-1970 as transistor penetration becomes an important factor in the initial equipment market.

TABLE VI

THE HOME ENTERTAINMENT MARKET

ESTIMATED PICTURE TUBE DEMAND

1960-1965

Renewal Market

Year	Units (Thousands)
1959	6,600
1960	6,800
1961	7,000
1962	7,100
1963	7,200
1964	7,300
1965	7,500

The renewal market demand for picture tubes is based on an analysis of the number and age of television sets in use. The replacement life cycle assumes the following rates.

Years in Use	Failure Rate
1st	5%
2nd	10%
3rd	15%
4th	20%
5th	30%
6th	15%
7th	5%
	100%

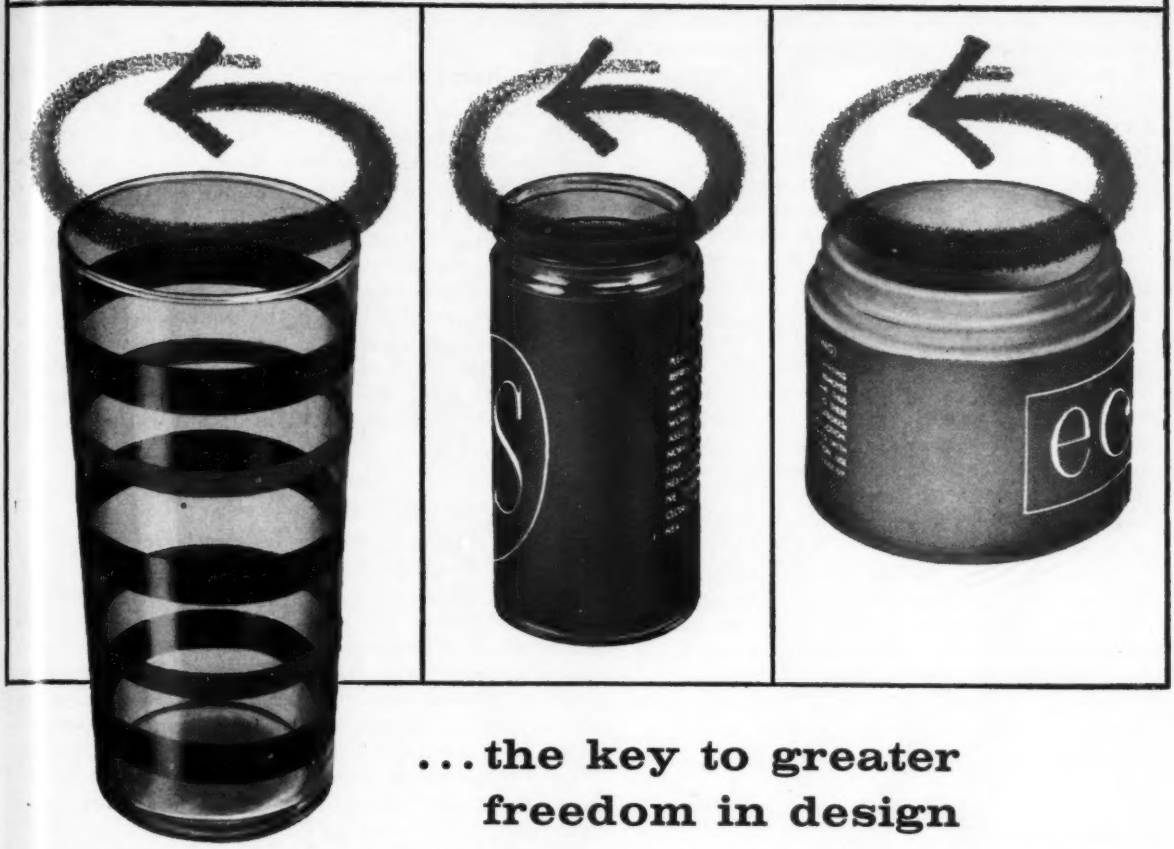
Lightweight Mirrors

High-power telescopes boosted into outer space will use a new lightweight mirror made of Pyroceram to achieve higher resolving power despite extreme temperature changes. Balloon and missile-borne telescopes, exposed to the weather, undergo rapid changes of temperature. The mirrors must retain the same curvature, regardless of environment, to record the constellations properly without interference of the earth's atmosphere.

The Pyroceram composition used in these mirrors has an expansion coefficient of essentially zero between −100° and +150°F, considered the temperature limits of airborne telescopes. A sandwich construction, two thin plates of Pyroceram held apart by short lengths of tubing, gives the mirror the high rigidity required for precise reflection plus the light weight necessary for space telescopes.

Pyroceram, like glass, can be ground and polished to high optical accuracy using standard techniques. The entire "sandwich" can be sagged to approximate curvatures to permit more economical finishing. Mirror weight

Wrap-Around Decorations



...the key to greater freedom in design

Now your designers can create far more attractive decorations for glass tumblers and containers — decorations *that completely encircle the ware.* No longer need your designs allow a blank space to start and stop the screen printing process. *Hot color printing* permits new latitude and artistry in decoration — wrap-around design that adds sales-making charm and beauty.

Drakenfeld ACL Enamels in Drakotherm are hot printing colors. Drakotherm is a quick-setting thermoplastic printing paste that has excellent working properties and uses medium range printing temperatures. No color-medium separation on prolonged heating, no sagging during firing, no offsetting in overprinting. The colors fire out easily — have a high gloss without screen marks.

Two or more colors can be applied consecutively without waiting. Results are sharp, clean, smooth even on fine details. Misprints are fewer. You save bottle rewashing time . . . save on color costs.

Fully automatic screen process printing with Drakenfeld Colors in Drakotherm combines mass production speed and economy with the extra buy appeal of attractive wrap-around decorations. We will gladly explain in detail. *Write for complete information.*

DEPENDABLE SERVICE ON: Acid, Alkali and Sulphide Resistant Glass Colors and Enamels . . . Crystal Ices . . . Porcelain Enamel Colors . . . Body, Slip and Glaze Stains . . . Overglaze and Underglaze Colors . . . Squeegee and Printing Oils . . . Spraying and Banding Mediums . . . Metallic Oxides and Chemicals.

CALL ON Drakenfeld

OUR PARTNER IN SOLVING COLOR PROBLEMS

B. F. DRAKENFELD & CO., INC.

Executive Offices: 45 Park Place, New York 7, N. Y.
Factory and Research Center: Washington, Pa.

Pacific Coast Agents:

BRAUN CHEMICAL COMPANY, 1363 So. Bonnie Beach Place
LOS ANGELES 53, California Phone: ANgelus 9-9311

BRAUN-KNECHT-HEIMANN COMPANY, 1400 Sixteenth Street
SAN FRANCISCO 19, Calif. Phone: HEmlock 1-8800

is also reduced to a minimum by this process. Since the material is transparent in its glassy state, the entire mirror blank can be visually inspected for defects such as bubbles and for proper sealing positions before the material is turned into a ceramic by heat treatment.

Available airborne mirror blanks have a diameter of 10 inches, using ¼-inch plate. However, Corning states, the size of future mirrors can be much larger or smaller, depending on requirements.

Fused Silica

Fused silica can be formed into cylinders, domes, crucibles, rods and slabs through an adaptation of Corning's Multiform process. Sizes equal to any achieved by conventional ceramic forming processes are possible. The development makes it possible to exploit the unique thermal and electrical properties of pure silica glass in many flight vehicle applications.

The material can withstand long-term use at temperatures over 1700°F and intermittent use to 2250°F. Softening point is 2880°F; Coefficient of thermal expansion, 3 x 10^{-7} per degree F, giving the material excellent resistance to thermal shock. Multiform fused silica is extremely viscous at high temperatures and tends to sublime before it can liquify and flow. Tests of the material in a plasma jet show uniform removal of sample surfaces by ablation.

The material also displays extremely stable dielectric constant and a low loss tangent over a broad temperature range. At a frequency of 8.6 x 10^{9} cps, the dielectric constant is 3.58 at 77°F and 3.57 at 750°F. At the same frequency, dielectric loss factor ranges from 0.00069 at 77°F to 0.00098 at 750°F. It has a density of 1.9 to 2 grams per cubic centimeter or 120 to 125 pounds per cubic foot and a porosity of 9 to 13.6 per cent.

Radiant Heater

An industrial radiant heater engineered for quick warm-up and cool-off has been developed for drying, baking, curing, and pre-heating. The Vycor brand radiant heater emits high efficiency long wave infrared rays from wire coils enclosed in tubes of 96 per cent silica glass. The heat is absorbed uniformly regardless of product color. The glass tubing is highly resistant to heat, heat shock and corrosion.

A triple reflector system directs 85 to 90 per cent of the available radiation onto the work. A strip of non-tarnishing platinum, fire-bonded to one side of the tube, literally bounces the heat toward the product. The housing, consisting of two layers of aluminized steel with fiberglass insulation between, provides additional reflection. By providing more useful heat per kilowatt, the unit cuts power costs. Since little heat is dissipated into the air, working conditions are more comfortable.

96 Per Cent Silica Glass

Applications include transparent nozzles for welding torches, and protective tubing for thermocouples used in determining the temperature inside metal-melting furnaces.

The nozzle of the welding torch has an inside ground joint which eliminates need for a gasket and fits over the welding point, allowing free flow of gas to the spot of the weld.

As a protective shell around the thermocouple, the Vycor brand glass goes directly into molten metal in electric arc and open hearth furnaces. In this application, the glass withstands a short-term temperature up to 3100°F.

Glass Heat Exchangers

Glass heat exchangers, manufactured by Q.V.F. Limited, of England, are now being sold in the United States through Corning Glass Works and its nationwide plant equipment distributors. These new coil type heat exchangers are compact, modular units. The glass shell surrounding a single glass tubing coil can be easily joined to standard American equipment.

These heat exchangers can also be used under sanitary operation procedure, as in the manufacture of drugs. The units vary in size from 2½ to 60 square foot capacities. The units can be operated in parallel or series and, with their compactness, can be installed directly on top of or below operating equipment without the use of cranes.

Photo-Multiplier Tube Spacers

Photo-multiplier tube spacers permit accurate reproduction of detailed and complex hole patterns by simple artwork. Made of Fotoform B and E, chemically-etchable glasses, the spacers can withstand the high operating temperatures of the tubes and have good electrical properties and great strength. They are made by a photosensitive process and can be produced to ±0.002″ hole diameter specifications. Because the spacers can be redesigned without costly re-tooling, they can be used to advantage for engineering samples and in development work where design of the tubes is constantly changing.

Lower tube production costs can be achieved since the same artwork used in development serves throughout the production run. The spacers are non-porous and have zero moisture absorption. They are hard and tough, possess excellent abrasion resistance, are free of internal flaws, and are dimensionally stable.

High Temperature Glass-Ceramic Frit

This thermo-setting solder glass-ceramic has sealing and service temperatures of 750°C.

The frit can be used in sealing alumino-silicate glasses to themselves, to molybdenum, or to tungsten, and in sealing molybdenum and tungsten to themselves. The frit will seal other materials which are in the expansion range of 40 to 50 x 10^{-7} and are capable of withstanding the 750°C sealing temperature. It will seal in vacuum, air, forming gas, and nitrogen.

The alumino-silicate glasses are used in the high-temperature tube field and are particularly applicable for high performance military power tubes, magnetrons, klystrons, and traveling wave tubes. They are resistant to neutron radiation damage and, being in the low expansion range, they have better shock resistance than lead or lime glasses.

Alumino-silicate glasses also can be used for cathode

Specify FOOTE Lithium Carbonate!

The attractions of lithium carbonate as a ceramic batch material are undeniable. It's readily smelted into frits for porcelain enamels and glazes. Low solubility permits use as a direct mill addition. It flows freely, won't cake, and can be stored indefinitely.

But even if lithium hydroxide or fluoride suits your needs better, you'll still do well to buy them from Foote. Few companies will go so far as Foote to satisfy your individual requirements for lithium minerals and chemicals. Lithium carbonate, for example, is available from Foote in unlimited quantities . . . in a high purity standard technical grade . . . in a variety of packages to satisfy your special needs. For the complete story, write Foote Mineral Company, 477 Eighteen West Chelten Building, Philadelphia 44, Pennsylvania.

FOOTE MINERAL COMPANY

ray tubes where extremely high temepratures are required in screen-baking transparent phosphors onto the face plate. They can be optically melted to produce face plates virtually free of defects.

Glass-Enclosed Film Resistor

A glass-enclosed, precision film resistor was introduced last year. A true glass-to-metal seal makes the resistor completely impervious to moisture and is said to be comparable to the glass-metal seal in an electron tube, and more resistant to physical shock.

The moisture-proof resistor has Dumet leads which are sealed to the thermally compatible glass case, creating a hermetic seal. The leads are welded inside the case to Kovar metal disks, which are fused to the resistance element.

Fused Quartz

Several new forms of quartz have been introduced in the last few years, including one of fiber made up of continuous monofilaments 0.0004″ in diameter. This can be woven into cloth and used as insulation and as a reinforcement for plastic materials to be subjected to ablative forces. Another form is a microbore capillary tubing with an I.D. of 0.002″ and an O.D. of 0.002″. Tubing with hexagonal and square cross sections is now being produced.

The addition of several new processes and techniques now permit the manufacture of quartz rod, tubing and such items as crucibles for semi-conductor processing to considerably closer tolerances than heretofore.

Quartz can now be produced that is practically free of boron. This is a necessary requirement when this contaminant must be kept under one part per million.

Immersion thermocouple tubes are also made by an improved process that produces several standard sizes with clear ends to a high degree of uniformity.

Clear fused quartz consists of pure silicon dioxide (SiO_2) called silica. The unrestricted use of "fused quartz" and "fused silica" has caused some confusion although from a strict terminology standpoint they are identical. Over the years "fused quartz" has come to be associated with the transparent variety while "fused silica" is commonly associated with the translucent type produced from high grade silica sand.

Clear fused quartz produced from rock crystal contains over 99.8 per cent silicon dioxide. After fusion, the tubing and rod is non-crystalline in structure, water white, and can readily be manufactured in a wide range of sizes and fabricated shapes. The coefficient of expansion of fused quartz is lower than that of any commonly known material over a wide temperature range.

Due to this extremely low expansion (0.55×10^{-6}) fused quartz can withstand extreme thermal shock. Tubing and rod can be subjected to red heat and immediately quenched or cooled in cold liquid or air without harm.

Clear fused quartz is made from high purity silicon dioxide. High standards of production and exacting requirements produce essentially boron free quartz.

Where fused quartz material is to be used at elevated temperatures, particularly in the neighborhood of 1000°C and above, it is extremely important that the surface of the material be free of any contamination if accelerated devitrification is to be prevented. Quartz will devitrify at these temperatures, over a period of time in any case. However, contamination of almost any kind will accelerate this condition.

Generally a solution of hydrofluoric acid of approximately 10 per cent concentration at room temperature is used to clean the material. This acid is used primarily because it is one of the few solvents for silica. Water is used to rinse. Five minutes in acid is usually sufficient time to clean the surface of the material and is a short enough time to prevent etching. It is important that the tube be free of fingerprints and oils before it is acid washed; to eliminate surface contamination, all fused quartz should be handled with cotton gloves.

A variety of standard quartz-ware is available for silicon and germanium crystal growing apparatus, and clear fused quartz is available in tubing (both round, non-circular and double bore), rods, ingots, plates and discs.

Clear Fused Quartz Yarn

General Electric's new quartz thread is spun from tiny monofilaments that are only 1/10th as thick as human hair. Made from rock-like crystals, the monofilament is twisted into thread and then woven into a fabric that withstands thermal erosion and retains its tensile strength at elevated temperatures far in excess of any other textile. Cloth made from this quartz thread imparts a greater per cent retention of strength to plastics, making them suitable for rocket and missile applications.

Continuous-length quartz (vitreous silica) fibers are similar to standard "E" glass continuous fibers. The multiple-fiber strand thus produced is processed on conventional textile twisting, plying and winding machinery to produce threads and yarns. These may be used directly on wire-serving equipment and on standard warping and quilling equipment prior to a weaving process.

TABLE VII*

COMPARISON OF PROPERTIES: CLEAR FUSED QUARTZ, "E" GLASS AND VYCOR GLASS (96% SILICA)

	Clear Fused Quartz	Typical "E" Glass	Vycor Glass
Density, gm./cc.	2.20	2.53	2.18
Young's Modulus, p. s. i.	10×10^6	12.7×10^6	9.7×10^6
Average Coefficient of Thermal Expansion, 1/°C. 0 to 300°C.	0.55×10^{-6}	4.2×10^{-6}	0.80×10^{-6}
Softening Point, °C.	1667	915	1500
Annealing Point, °C.	1140	720	910
Strain Point, °C.	1070	675	820
Dielectric Constant/Mc., 20°C.	3.78	6.3	3.8
Power Factor/Mc., 20°C.	.0002	.0037	.00024
Loss Factor/Mc., 20°C.	.0009†	.023	.00091
Index of Refraction (Sod. D)	1.458	1.534	1.458
Thermal Conductivity at 0°C. g.cal./cm.^{2}/sec./°C./cm.	.0033		
True Specific Heat at 0°C. g.cal./g—°C.	.165	.170	

* Based on information contained in "Glass Engineering Handbook" by E. B. Shand, Section Edition, 1958 (except as noted).
† General Electric Quartz Catalog.

Fused Quartz Yarn Fiber Mats

Two types of fibers are available:

A. 200-filament continuous quartz yarn. Packaged on returnable throwing bobbins containing 1 to 1½ pounds per bobbin.

B. Mats of quartz fiber of 0.001″ diameter. A typical mat—24″ long, 9″ wide, and ¼″ thick. The 0.001 inch fibers are laid together longitudinally. Mats are normally supplied without a binder but can be produced with binders or sizing compounds.

Quartz yarn in other forms, and quartz mats of fibers other than 0.001 inch diameter and mats of different package dimensions can be produced to fill most requirements.

ULTRASONIC CLEANING

(*Continued from page* 87)

Similar results are obtained by a manufacturer of diodes. Hollow, glass sleeves, measuring no more than ½-in. OD, have to be completely free from chips or any organic contaminants, lest these interfere with diode operation after sealing. Ultrasonic cleaning has proven to be the most effective in insuring consistently superior operation.

Handling Small Pieces

Small pieces are usually placed individually on racks or in baskets, loaded not deeper than six times the smallest part dimensions. Basket mesh should be kept as large as possible, consistent with the size of the parts to conserve transmitted energy.

Placed individually on racks, small fragile parts are protected from breakage and exposed on all surfaces to the gentle cleaning action of the ultrasonic vibrations. Free circulation of fluid eliminates the danger of entrapped air and increases cavitation.

When a drilled hole had to be so small (0.0003 in.) as to make hand cleaning almost impossible, a manufacturer of diamond dies installed ultrasonic cleaning equipment in order to remove the buffing and drilling compound. There were fewer rejects, and the finished product was more valuable because the holes were smaller and more uniform.

Surgical instruments and hospital glassware are cleaned ultrasonically with minimum breakage and maximum convenience. Most rewarding service is the cleaning of hypodermic syringes with stuck plungers. Formerly discarded, they are batch-loaded and subjected to ultrasonic vibration for about 10 minutes. The majority are unsealed immediately; a few require additional treatments before yielding. While not sterile, all traces of protein matter or serum are removed, and autoclaving finishes the job.

Equipment Size

The guiding factor in choosing a cleaning tank is the amount of energy (r-f watts) used under working conditions per gallon of cleaning fluid. Ideally, only one layer of work should pass close to the radiating surface of the transducers, and cleaning fluid should just cover it. Unlined metal tanks, of minimum size, should therefore be selected.

The number of transducers used depends on the size and number of parts to be processed, and the exposure time required. These factors can usually be found by trying out a small-scale cleaning operation, and then determining the number of transducers required for the standard operation.

At the present time, generators with power outputs up to 5-kw are stocked. These high-powered generators may activate a single installation or several units. Larger generators can be designed and built to specific requirements.

Cleaning Liquid

Although cleaning agents in normal use often work better in ultrasonic equipment, future experiments may reveal more effective detergents or cleaners.

Ultrasonic equipment, as part of a conventional degreasing system, can also be made available by a number of companies. Furthermore, a new model cleanliness tester has just recently been introduced by Branson Ultrasonic Corp. to help the production engineer evaluate the effectiveness of various cleaning processes, materials, and equipment.

Summary

It has been shown many times that small glass items or parts of glass-handling machinery can be cleaned efficiently in batches by ultrasonic methods. Untended production lines, such as the one developed by Hodes-Lange, have also proven highly successful. The only thing still to be tried by the glass manufacturer is the use of ultrasonic equipment for production cleaning of flat plate glass or large castings. Ultrasonic manufacturers feel confident that equipment can be engineered to handle them.

CERIUM IN THE GLASS INDUSTRY

(*Continued from page* 86)

1930's and became widely accepted in this country during World War II and thereafter. The increasing acceptance of cerium has been brought about by its more rapid polishing rate, ease of handling, cleanliness, and brilliance of the polish achieved.

In general, two grades of cerium oxide are available and sold for glass polishing. The first is actually a mixture of oxides containing 45 to 50 per cent CeO_2 whose composition corresponds to that given in Table I for rare earth oxide. The second is a concentrated form of ceric oxide containing 90 per cent minimum CeO_2. Inasmuch as cerium dioxide is the only rare earth oxide with ability to polish, the other sesquioxides (trivalent oxides) do not act as polishing agents and are really inert diluents in these preparations. In its ability to polish glass, ceric oxide is analagous to some forms of titanium, zirconium and thorium dioxides, which also exhibit this property, but CeO_2 is by far the best glass polishing agent.

The physical form of these polishing preparations is a factor in their performance, and generally the higher

the CeO_2 content, the faster the polishing rate attained. For use in polishing systems where the polishing slurry must be pumped long distances, a suspension treated form of both types is available that will not settle out as easily as do the untreated forms.

The 45-50 per cent grade has a brown color, and the 90 per cent grade is a flesh-colored product. Both grades are insoluble in water, organic solvents and in most acids. They are easily removed from tools, glass, clothing and hands by washing with water—distinct advantages for operators as compared with the use of rouge.

Cerium oxide is used to polish spectacle lenses, precision optical parts, other ophthalmic, camera and instrument lenses; cut glass and stemware; glass specialties; and pink and red granite, marble and semi-precious stones. Because of its fast glass removal rate, it is used to "block" mirror glass prior to silvering, as well as to edge bevel mirrors. For the same reason it is also used for removing scratches from plate glass for mirrors and automobile windows.

Decolorizing

Because of its powerful oxidizing effect, cerium oxide is an excellent glass decolorizer. The action depends upon the reaction which takes place at the glass melting temperature:

$$4CeO_2 \longrightarrow 2Ce_2O_3 + O_2$$

As the temperature is lowered, some of the liberated oxygen is consumed by the reverse reaction. Cerium oxide has a much stronger oxidizing action on iron than do other commonly used oxidizing agents, and generally gives a greater proportion of colorless iron in the glass. Any light ferric iron color remaining after the addition of cerium oxide may be eliminated by physical decolorizers such as neodymium oxide, selenium, manganese dioxide, cobalt oxide or nickel oxide.

Rare earth hydrate or oxide or didymium compounds can also be used as physical decolorizers, since all contain neodymium. Didymium refers to the mixture of rare earths remaining after the cerium has been removed from the rare earth salts or compounds. Since the rare earth hydrate, the oxide or sodium sulfate double salt each supply cerium as well as neodymium, these materials sometimes can be used as is for both chemical and physical decolorizing. Glass decolorized with cerium and didymium is remarkably clear and does not have a gray appearance.

When cerium is used for decolorizing, the glass must be free of arsenic, even in trace amounts, since arsenic causes a deep brown color to appear when the glass is exposed to diffuse daylight. In other words, glass containing cerium and arsenic is photosensitive.

The permanent oxidizing effect of cerium results in a glass whch is stable toward solarization, and this stability continues during subsequent high-temperature exposures in such operations as decorating, reheating and reworking. Cerium is an efficient oxygen carrier and is used in conjunction with sodium nitrate.

TECO

IN THE GLASS
CENTER OF THE WORLD

Offering a complete service to all branches of the Glass Industry

- Glass Melting Furnaces
- Fuel Oil Systems
- "Air-Clad" Gas Burners
- "Univerbel" Batch Charger
- "Austel-Escher" Recuperators and Firing Systems
- Annealing and Decorating Lehrs
- "Hydrostatic" Bottle Testers

ENGINEERS – DESIGNERS – CONTRACTORS

TOLEDO ENGINEERING Company

3001 Sylvania Ave., Toledo 13, Ohio
GReenwood 5-1529

For example, with glass sands containing not over 0.06 per cent Fe, about 1 to 2 pounds of ceric oxide (CeO_2) together with 5 to 10 pounds of sodium nitrate per 1,000 parts of sand are required. An excess of cerium in the glass is not harmful. The amount of physical decolorizer required generally is much less than the amount normally needed because of the permanent oxidizing condition imparted by the presence of the cerium. With 2 pounds of ceric oxide about 8 ounces of manganese dioxide per 1,000 pounds of sand produce satisfactory decolorization.

Coloring

The formation of colors in glass with cerium depends upon the formation of cerates of other metals, these cerates having the general formula, $MCeO_4$, where M is a tetravalent metal like titanium or lead. When ceric oxide is used with titanium dioxide, a beautiful yellow titanium cerate glass is produced. With lead glasses, brown colors are often formed. Figure 2 gives the absorption spectrum of a yellow titanium cerate glass containing 1.2 per cent CeO_2. The yellow titanium cerate color can be changed to orange by the addition of manganese dioxide. Small amounts of copper oxide with titanium cerate give a turquoise color in potash glass.

Ultraviolet Absorbing Glass

Rare earth compounds (with the execption of those of lanthanum, lutetium and yttrium) are unique in exhibiting rather sharp absorption bands in the ultraviolet, visible and infrared parts of the spectrum. Cerium compounds are opaque to ultraviolet light, and in glass they eliminate the transmission of ultraviolet light without affecting the visible color of the glass.

It follows, therefore, that it is now possible to package materials which are harmed or spoiled by ultraviolet radiation in *clear* container glass made of cerium. This opens up an entirely new field of packaging applications for clear glass where formerly only amber or brown glass was used. While both types of glass are effective in preventing ultraviolet rays from reaching the contents, the clear glass has a definite sales advantage as a package because it shows off the product.

Before presenting data on the radiation absorbency of glass of several compositions, it is well to review the subject of ultraviolet radiation. Table V lists the wave lengths of various radiations in Angstrom units.

Ultraviolet radiation has a range of wave lengths from 136 to 3900 Å, and the atmosphere transmits solar radiation wave lengths down to somewhat below 3000 Å. Ordinary glass transmits ultraviolet rays very well (80 per cent or more transmission) in the range of 3400 to 3900 Å. The best wave length for ultraviolet rays having therapeutic value is 3020 Å, which is the reason why ordinary glass blocks filter out the beneficial values of the ultraviolet portion of sunlight.

On the other hand, the atmosphere itself blocks the transmission of the harmful ultraviolet rays of the sun below 2920 Å. This is due primarily to the ozone pres-

How well do you know your glass?

THIS IS A:

- ☐ 1. Space helmet
- ☐ 2. Lighthouse light
- ☐ 3. Centrifuge
- ☐ 4. Kinetoscope

The kinetoscope was an early motion-picture device. But if you checked Number 4, you erred . . . because shown at right is a revolving lighthouse light equipped with an annular lens. The first such annular lens was developed by Augustin Fresnel in 1822. Sixty-eight years later Wyandotte began to supply Soda Ash to the glass industry. Today, as in the past, Wyandotte is a working partner supplying technical assistance and raw-material chemicals to those great companies marking milestones in glass progress.

Wyandotte CHEMICALS

Michigan Alkali Division, Wyandotte Chemicals Corporation
Wyandotte, Michigan • Offices in principal cities

Founded by a Glassmaker to Serve the Glass Industry

ent in a diffuse layer (the ozonosphere) within the stratosphere which is responsible for absorption of the shorter wave lengths of ultraviolet radiation. If this absorption did not take place, the excessive ultraviolet radiation at the earth's surface would be fatal to most forms of life.

The absorption spectra of pure cerous chloride ($CeCl_3$), of pure ceric ammonium nitrate and of mixed rare earth chloride solutions are presented in Figs. 3, 4 and 5, respectively. These absorption curves were obtained in a Carey spectrophotometer using 5 cm cells and all measurements were made against water as a reference standard. The chloride solutions were prepared to contain only traces of free hydrochloric acid and were nearly neutral.

Figure 6 shows the ultraviolet absorption spectra[10] for colorless glass containing ceric oxide, compared with flint or soda-lime, green and amber glasses. The 1.5 and 3 per cent additions are in flint glass and the 4 per cent is in borosilicate glass. Inasmuch as the measurements of transmission are not corrected for reflection, which amounts to about 4 per cent of the incident radiation from each surface, the maximum transmission reached is 92 per cent. This means that at 92 per cent transmission none or very little of the incident radiation is absorbed.

It will be noted that the presence of 1.5 per cent CeO_2 causes the absorption of ultraviolet radiation up to a wave length some 50 millimicrons higher than do soda-lime or flint glasses. Further, the transmission in the visible range is essentially the same as for the latter types of clear glass. The use of larger proportions of ceric oxide increases the range of ultraviolet wave lengths absorbed.

In making ultraviolet absorbing glasses with cerium, the cerium can be added in other forms than cerium oxide. For example, the crude material, rare earth sodium sulfate, which contains about 21 per cent CeO_2 and which is much cheaper, can be used. Its use has been verified by actual batch tests.

Cerium used for preventing ultraviolet transmission also acts as a decolorizer at the same time, so both results can be obtained with the same addition of cerium or cerium-containing material to a glass batch. As mentioned in the section on decolorizing, a physical decolorizer is also added to neutralize the color of ferric iron imparted by the oxidation of ferrous iron by the ceric oxide.

Applications

Ultraviolet-absorbing glass has a variety of applications. As first proposed by Sir William Crookes in 1914, the so-called "Crookes glasses" were used for ultraviolet protection in spectacle lenses; they contained 2 to 4 per cent CeO_2. In general this type of glass is valuable in protecting light-sensitive materials where a colorless, or nearly colorless, glass is desired or required.

The greatest potential for this glass is in the container field. Many materials packaged in glass are light-sensitive, in that their appearance, stability, color and taste are altered adversely by ultraviolet radiation. Among such materials are many kinds of foods, beer, wines, milk, vegetable oils, hypochlorite bleaching solutions, and pharmaceuticals.

Ultraviolet radiation promotes photochemical reactions that involve a wide variety of organic compounds. Those compounds that are susceptible to oxidative effects are the ones most affected by exposure to ultraviolet. This includes compounds containing alcohol (–OH), or ketone (=O) groups, or unsaturated bonds. Many vitamins are especially sensitive to ultraviolet radiation. For instance, the riboflavin (vitamin B_2) content of milk is rapidly decomposed when milk is exposed to sunlight, or when a bottle of milk remains outdoors for any length of time. In liquids like beer and wine the adverse effects include the development of visible cloudiness, as well as the development of unpleasant odors. In general, the shorter the wave length of the radiation, the greater the effect of the photochemical reaction. Hence the desirability of absorbing in the glass the broadest possible range of wave lengths of incident radiation.

The use of cerium in glass containers for such products prevents or decreases these adverse effects.

Table V

Wave Lengths of Various Radiations

[1 Angstrom (Å) = 10^{-8}cm = 10^{-4}microns (μ) = 10 millimicrons (mμ)]

	Angstroms
Cosmic rays	0.0005
Gamma rays	0.005-1.40
X-rays	0.006-1019
Ultraviolet rays	136-3900
Visible rays	3900-7700
Violet	3900-4220
Blue	4220-4912
Green	4912-5350
Maximum visibility	5560
Yellow	5350-5860
Orange	5860-6470
Red	6470-7700
Infrared rays	7700-2.2 x 10^6
Solar radiation reaching the earth	2960-53,000
Hertzian waves	1 x 10^6 to 3 x 10^{14}

Solarization and Other Radiation Effects

In addition to its other effects in glass, cerium also serves to prevent discoloration caused by high-intensity gamma radiation from radioactive sources. Radiation protective windows are susceptible to such discoloration, but about 0.25 to 1.5 per cent CeO_2 in such glasses makes them suitable for this use. Cerium oxide also imparts similar retardation to discoloration in cathode-ray tubes.

Glasses containing cerium and arsenic, as noted previously, undergo solarization even in diffuse sunlight. Glasses containing vanadium and cerium oxides undergo a color change from the green given by V^{+3} through a gray, a pink, and then a purple in daylight. This photosensitivity is used in the determination of daylight intensities for climatological work. It is also used to measure intensities of ultraviolet radiation, since the rate of color change is proportional to the amount of radiation received by the glass. The color change is due to the reaction:

$$V^{+3} + Ce^{+3} \longrightarrow V^{+2} + Ce^{+4}$$

Photosensitive glasses based upon gold, silver and copper as the image developing elements are made much

more sensitive to ultraviolet radiation by the presence of small amounts of cerium. The effect of cerium undoubtedly is due to the oxidation of trivalent cerium by the metal ion, as by the reaction involving copper:

$$Ce^{+3} + Cu^{+1} \xrightarrow{h\nu} Ce^{+4} + Cu$$

The image is developed by heating the glass, which makes the process irreversible due to the aggregation of the free copper into larger particles.

Cerium glasses exhibit phosphorescence and fluorescence, the optimum amount of cerium to produce maximum fluorescence being in the range of 0.6 to 0.7 per cent Ce_2O_3. Trivalent cerium absorbs ultraviolet energy and releases it in the form of light in the wave length range of 300-480 mμ. This property is used in some phosphors to increase the efficiency of manganese activation to produce fluorescence. All cerium glasses show thermoluminescence.

Economics

For the past few years the cost of cerium compounds and cerium-containing materials has been decreasing, a trend which should continue as greater consumption of these products occurs. This trend should in turn stimulate the use of cerium in the glass industry.

Some of the current prices for commercial quantities of cerium oxide and cerium-containing materials are given in Table VI.

Table VI

	Price per lb
Cerium hydrate, 83% min. CeO_2	$1.40
Cerium oxide, 90% min. CeO_2	1.90
Cerium oxide, 99.5% min. CeO_2	5.00
Rare earth sodium sulfate, 20.6% CeO_2, 43% total rare earth oxides	0.16 or 0.77/lb contained CeO_2
Rare earth chloride, 22% CeO_2, 46% total rare earth oxides	0.18 or 0.82/lb contained CeO_2
Glass polishing products	
Concentrated, 90% CeO_2 grade	1.90
Rare earth oxide grade, approx. 45% CeO_2, bal. chiefly other rare earth oxides	1.60

REFERENCES

1. Wartenberg, H.v., and Gurr, W., Z. anorg. allgem. Chem., *196*, 374-83 (1931).
2. Wartenberg, H.v., and Eckhardt, K., ibid, *232*, 178-87 (1937).
3. Wartenberg, H.v., Ruesch, H. J., and Saran, E., ibid. *230*, 257-76 (1937).
4. Wartenberg, H.v., and Prophet, E., ibid. *208* 369-79 (1932).
5. Wartenberg, H.v., and Ruesch, H. J., ibid, *207*, 1-20 (1932).
6. Veil, S., Compt. rend., *170*, 939-41 (1920).
7. Passerini, L., Gazz. chim. ital., *60*, 762-76 (1930).
8. Ruderoff, W., and Valet, G., Z. Naturforsch, *76*, 67 (1952).
9. Hund, F., Wagner, P., and Peetz, U., Z. Electrochem., *56*, 61-65 (1952).
10. Kapnicky, J. A., and Koehler, W. A., J. Am. Ceramic Soc., *31*, 321-2 (1948).

STUDY OF GLASS AND MOLD TEMPERATURES

(*Continued from page* 81)

the heel [up to ½ inch] commonly show continuous cooling, but may show a plateau and even reheating after delivery. The bottom glass temperatures generally show a plateau at blow air release or upon delivery, followed usually by reheating after the plateau.

2. The practical end of the working range for round bottles is log 7.1 to log 7.7, and for flasks with flat side sections, log 8.8. (See section 3.1.)

3. Hot areas are indicated in the lower sidewall, where "out-of-shape" is common. A second hot area may be at the shoulder early in the cycle, which becomes less pronounced upon delivery of the bottle. Inner seam hot areas are usually slightly lower down on the sidewall than front seam areas.

4. The gradation and regularity of temperatures on vertical sections at right angles to the seams are improved over similar positions on front and inner seams. Usually the inner seam is better than the front seam in this regard.

5. No definite relationship can be given concerning glass surface temperatures on a horizontal section of the bottle. However, usually the inner seam is hotter than the outer seam. In some cases, the position at right angles to the seam is hotter than either the outer or inner seam, although, more generally, it will be the coldest position.

6. The surface of amber glass cools much more rapidly than that of flint glass, resulting in a viscosity change at the surface five times as great for amber as for flint during the time from one to two seconds after the blow air is applied. This condition results in more or less erratic behavior of the amber glass surface temperature after the blow air is released, due probably to a greater differential between surface and interior of the glass section developed by the rapid temperature change at the surface.

7. Each bottle is, in general, individual and distinct in its glass surface temperature. Due to frequent exceptions, accurate predictions cannot be made on the basis of the available data.

3.7. Glass Temperature Measurements, Miller Operation

The spread of individual values for Miller glass temperature for any specific position is approximately the same as for Owens operation. A group of Miller jobs from 7½ to 32 oz. capacity were measured, some in combination with mold temperatures. The data herein presented is typical, and the amount reported is therefore limited. Gob shear is zero time on these data.

A 10¾ oz. capacity, 10½ oz. weight mustard jar gave the front seam sidewall data shown in Figure 5. These data are tabulated in Table 5. The hot spot in this bottle is 1½ to 2 inches up on the front seam, and at a little higher position on the inner seam. The heel of the bottle shows a slow cooling during the machine blowing and then it becomes much colder later after the bottle delivers. This perhaps indicates a slow blow-out to the heel, but then rapid cooling when contact is made.

Data on a 16 oz. capacity round mayonnaise container, weight 9⅞ oz., is given in Table 6. This is a lightweight jar with uniform temperature over its surface. At comparable upper sidewall positions the 90°-to-seam glass temperatures run about 80—100°F hotter than the seams during the machine cycle, but this changes to a hotter condition at the inner seam at the time the bottle goes to the lehr. These conditions do not prevail through the lower ½ inch of the sidewall, where the inner seam is colder. Early in the cycle a cold spot is indicated 2¼ inches up on the sidewall on the front seam, but

Delos M. Palmer & Associates

Consulting Engineers

Mechanical, Electrical & Industrial

Designers of
Special Purpose Machinery
For The Glass Industry
Automation

4401 JACKMAN ROAD TOLEDO 12, OHIO

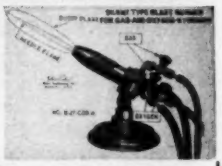
Telephone: Greenwood 9-4453

EISLER Equipment

solves glass problems!

Since 1920, designers and builders of special machinery and equipment for the glass industry.
Glass Lathes • Glass Cutters • Wet or Dry Silent Blast Torches • Cross Fires • Ribbon Fires • Gas and Oxygen Burners • Indexing Turntables • Sealing, Ampule and Bulb Blowing Machines, etc.
Call us now without obligation

Above: SPECIAL CROSSFIRES
Below: BLAST BURNERS



EISLER ENGINEERING CO., INC.
742 So. 13TH ST., NEWARK 3, N. J.

Charles Eisler, Jr.
President

THE SHARP-SCHURTZ COMPANY

CHEMISTS AND CONSULTING ENGINEERS
FOR THE GLASS INDUSTRY

LANCASTER, OHIO U. S. A.

M. L. CAMPBELL CO.

ELECTRICAL ENGINEERS

COMPLETE
DESIGN LAYOUT INSTALLATION
TO
THE GLASS INDUSTRY

P. O. BOX 221 BETHEL PARK, PENNA.

Wilson 1-7037

this becomes a hot spot when the bottle enters the lehr. At 90° to the seam the cold spot is 1¼ inch up on the sidewall, while on the inner seam this is a hot spot.

3.8. Generalizations on Miller Glass Temperatures

There are generalizations evident from the data, as follows:

1. In general, there are few breaks or hesitations in the glass temperature curves during fabrication on Miller machines. Bottles of capacities of 16 oz. or more show an improvement in their temperature gradient (toward better uniformity of temperature) as they progress from the machine into the lehr, while a tendency to show no particular change one way or the other appears to prevail for smaller bottles.

2. Two hot areas are usually indicated, in a varying degree, when the bottle enters the lehr. These are on the lower sections of the sidewall and on the shoulder of the bottle.

3. There is no relationship between the various sizes of bottles and their temperatures at any point in the cycle.

4. In most instances, there is a location on the sidewall of a bottle near its bottom where the inside seam is colder than the outside seam. Somewhat higher on the sidewall, the reverse is apt to be true; that is, the inside seam is hotter than the outside seam.

5. The temperatures at positions at right angles to the seams do not show a consistent relationship to those on the inside and outside seams. More generally, these temperatures are intermediate between those at the seams, but in many cases they are lower and, occasionally, somewhat higher.

6. The lower end of the working range for Miller wide-mouth ware is from log 6.1 to log 7.2. (See Section 3.1.)

3.9. Comparison of Miller and Owens Glass Temperature Data

Comparisons on Owens and Miller glass temperature data cannot be made too specific, as obviously the processes differ (vacuum vs. press and blow) and the product is generally different (narrow neck vs. wide mouth). Comparisons of double cavity vs. single cavity are not legitimate. The most obvious comparison is that Miller glass temperatures show less breaks in the cooling curves. However, the spread of results around the bottle are similar for both machines and the locations of hot spots vertically vary according to expectations. Working range comparisons have already been made. Miller ware generally shows slower cooling during blowing due to the station-cycle operation. Miller speeds are not generally limited by the glass temperature where the jar goes out of shape, but rather by the mechanical limitations of the pressing station. However, the temperatures for the end of the working range are higher for Miller than for Owens. This is due to the lesser gradient through the glass wall section—a result of the pressing action with metal contact on both sides of the parison—and also perhaps somewhat lower wall thickness for Miller than for Owens operation. A generalization on the flow process blow-and-blow narrow-neck operation would be helpful.

NEW BOOKS

(*Continued from page* 98)

Microscopical Evaluation of Cotton Finishing Treatments. Mary L. Rollins, Ines V. DeGruy, Verne W. Tripp, and Anna T. Moore; Southern Regional Research Laboratory, Southern Utilization Research and Development Div., Agricultural Research Service, New Orleans, La., U. S. Department of Agriculture.

INVENTIONS

(*Continued from page* 97)

thicker glass sections, and as a result the tensions which are produced in the thinner sections are much below the tensions normally permitted for making such glass joints, according to indications of a glass tension meter or of polarized light.

There were 7 claims and the following references cited in this patent.

United States Patents

1,748,587, Smedley, Feb. 25, 1930; 2,494,582, Propopec, Jan. 17, 1950; 2,521,048, Day, Sept. 5, 1950; and 2,522,523, Lukes, Sept. 19, 1950.

Miscellaneous Processes

Protective coating for decorated glassware and method of application. Patent No. 2,895,846. Filed May 25, 1955. Issued July 21, 1959. No sheets of drawings; none reproduced. Assigned to Owens-Illinois Glass Co., by Earl F. Schaefer.

A method of producing a decorated glass container is described which bears an additional protective coating capable of improving the water and abrasive resistance of the decoration, said method comprising the continuous, uninterrupted sequence of steps:

(1) applying a temperature hardenable printing ink decoration to selected areas of the glass container,
(2) heating said glass container to a temperature above 450° F to bond the printing ink decoration thereto,
(3) lowering the temperature of the decorated glass container to a temperature of between 300° F and 400° F,
(4) subjecting said decorated glass container to a fine spray of an aqueous emulsion of a silicon resin constituting from 0.5% to 2.0% by weight of the total weight of emulsion until the entire external surface of the decorated glass container is provided with a uniform coating while within said range of temperature,
(5) maintaining said silicone coated decorated glass container within said temperature range until said coating is cured, and
(6) cooling said decorated coated container to room temperature.

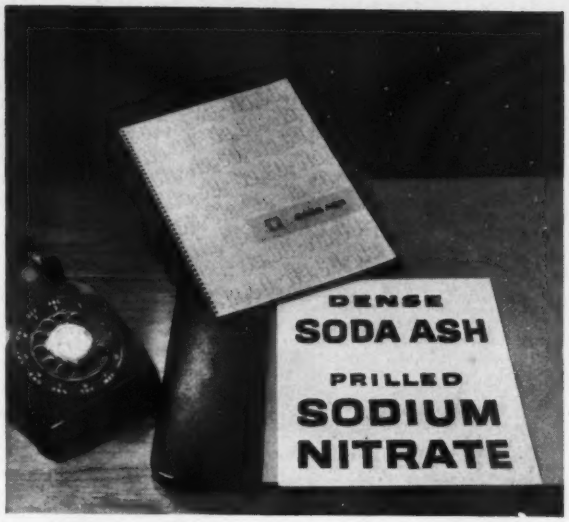
There were 2 claims and the following references cited in this patent.

United States Patents

2,023,175, Kneip, Dec. 3, 1935; 2,428,357, Cohen, Oct. 7, 1947; 2,436,304, Johannson, Feb. 17, 1948; 2,495,306, Zurcher, Jan. 24, 1950; 2,583,919, Biefield, Jan. 15, 1952; 2,588,828, Greiner, Mar. 11, 1952; 2,726,172, Bennett et al., Dec. 6, 1955.

CLASSIFIED ADVERTISEMENT

ENGINEERS - DRAFTSMEN experienced in glass container plant design and construction. Reply to Arthur W. Schmid International, Inc., 1414 Investment Building, Pittsburgh 22, Pennsylvania.



call
OLIN MATHIESON
CHEMICALS DIVISION
BALTIMORE 3, MARYLAND
6391

helping the glass industry produce better glass with better silica products . . .

OTTAWA
SILICA SANDS

THE WORLD'S FINEST SILICA SAND

Headquarters for highest purity and greatest uniformity in Silica.

99.9% PURE
BY ACTUAL LABORATORY TEST

OTTAWA
SILICA COMPANY
PLANTS LOCATED IN
OTTAWA, ILL. & ROCKWOOD, MICH.

SERVING THE FOUNDRY, GLASS AND CERAMIC INDUSTRIES FOR OVER 50 YEARS